31P Chemical Shift Imaging of Testicular Infertility at 3.0 Tesla

J. P. Dyke[1,2], D. A. Paduch[3], J. Kiper[3], E. Aronowitz[1], P. N. Schlegel[3], and D. Ballon[1,2]

[1]Citigroup Biomedical Imaging Center, Weill Cornell Medical College, New York, NY, United States, [2]Radiology, Weill Cornell Medical College, New York, NY, United States, [3]Urology, Weill Cornell Medical College, New York, NY, United States

Introduction: Male infertility affects approximately 4-6% of men between the ages of 15 and 50 and is a contributing cause in 40% of cases of infertility in couples. In severe forms of male infertility, surgical extraction of regions of the testis is required to isolate sperm for use in in-vitro fertilization procedures (IVF). While the technique of testicular sperm extraction (TSE) is successful in approximately 50% of men, there is currently no in-vivo imaging technique that can guide surgeons as to specific testicular quadrants that may contain viable sperm. In addition, there are no tools to follow testicular deterioration over time which may aid clinicians in deciding when to intervene or change therapeutic regimens.

We performed a prospective study of 11 subjects to non-invasively assess the degree of infertility using ^{31}P-MRSI. Metabolic peak areas were correlated with testicular biopsy results that confirmed the presence of viable sperm. Previous single-voxel ^{31}P studies at 1.5 Tesla showed that the peak area ratio of phosphomonoester (PM) to that of β-ATP decreased with various causes of testicular failure (1,2). We propose that ^{31}P chemical shift imaging (CSI) at 3.0 Tesla may provide localized spectroscopic information that may aid in clinical localization of viable sperm prior to TSE eventually increasing the chances of success for future in-vitro fertilization procedures.

Methods: MRI studies were acquired on a 3.0 Tesla GE MRI scanner using an 8-channel torso phased array coil. A single loop rectangular surface coil [13 pF + (6-40 pF) variable capacitor] of dimensions 4.5 cm x 6.5 cm was built in-house with an inductively coupled drive loop tuned to 51.62 MHz. The coil was placed in an electrically insulated housing and a thin plexiglas ring surrounded with tubing containing a small amount of oil was secured to the top of the housing. Subjects were positioned prone with the testes descending directly onto the top of the housing. Manual shimming was performed at the proton resonance on a single voxel containing the testes. ^{31}P spectroscopy was acquired using a single pulse CSI sequence (fidcsi) with a 3 cm slice select pulse in the coronal plane for a scan time of 19 min. The plane of interest was obliquely adjusted in order to minimize contamination from adjacent muscle. The sequence acquired a 6 x 6 grid of voxels (27 cc) with a repetition time (TR) of 1.0 sec, a sweep width of 2500 Hz, 2048 points, 32 averages and an 18 cm field of view. Processing of the MRSI data utilized zero-filling once in time and space to yield a matrix size of 12 x 12. Voxels were manually phased in $0^{th}/1^{st}$ order and baseline corrected prior to fitting via a Lorentzian line shape with XSOS (Shungu/Mao). A T_2-weighted coronal image matching that of the CSI data set was acquired for overlay of the spectroscopy data.

Patients were allowed to rest and re-position themselves in a supine position to complete T_2-weighted images using an 8-channel torso phased array coil. Clinical imaging sequences included 2D FSE T_2-weighted images in each orthogonal plane with acquisition parameters of a 7 sec repetition time (TR), a 103 ms echo time (TE), 90° flip angle, 28 cm field of view (FOV), a 256 x 192 matrix and a 5 mm slice thickness.

Results: 3 of 11 subjects did not contain viable sperm upon testicular sperm extraction. One subject contained contribution from phosphocreatine (PCr) and was excluded as PCr is not present in the testis but originated from adjacent skeletal muscle. The resulting PM/β-ATP ratio for those subjects that were found to have viable sperm (n=7) was 2.22 ± 0.41 ($\mu \pm \sigma^2$) compared to 1.60 ± 0.17 for those without viable sperm (n=3). A two-tailed non-parametric Mann-Whitney test for small sample sizes yielded a p-value of 0.03 between the means of these two groups.

Discussion: Future application of this technique will focus on subjects with Klinefelter syndrome and other severe forms of male infertility to serially monitor testicular deterioration. This information may aid clinicians in tailoring treatment therapies such as hormone replacement therapy (HRT) on a patient specific basis and allow more rapid intervention during the course of the disease.

References: 1) Chew WM, Hricak H, McClure RD, Wendland MF. Radiol 1990;177:743-747. 2) van der Grond J, Lavem JSE, te Velde ER, Mali WPTM. Radiol 1991;179:433-436.

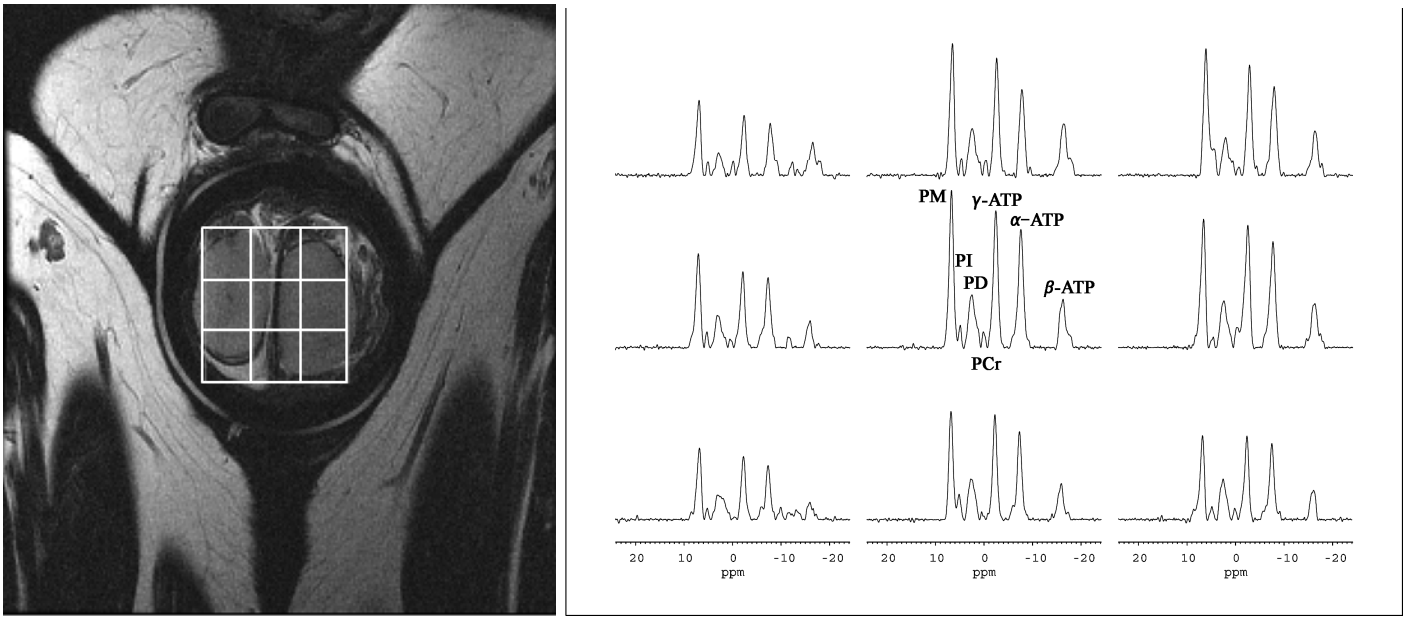

Figure 1: A T_2-weighted image illustrates coil positioning and a central region of voxels zero-filled to 1.5 x 1.5 x 3 cm. Representative baseline corrected spectra are shown prior to peak area fitting. This subject had a PM/β-ATP ratio of 2.16 ± 0.20 having viable sperm via TSE.