MAGNETIC RESONANCE IMAGING OF NORMAL AND BENIGN CONDITIONS OF THE URINARY BLADDER

J. Manavis, E. Kaldoudi, P. Antoniou, S. Deftereos, S. Touloupidis

School of Medicine, Democritus University of Thrace, Alexandroupolis, Greece

contact: {imanavis, kaldoudi, sdefter}@med.duth.gr

1. Purpose

To study the magnetic resonance tissue characteristics of urinary bladder structures in 1.0T in order to determine optimal imaging parameters for enhanced contrast in depicting the bladder wall against fat and urine in normal and benign conditions of the urinary bladder.

2. Background

Relaxation times help determine the contrast in MR images and directly affect the selection of image pulse sequence timing parameters. A large number of techniques for measuring T1 and T2 relaxation times in tissues have been reported [1,2].

However, relaxation parameters in the human abdomen have been determined only rarely [3,4], and as a consequence routine bladder imaging protocols are seldom finely tuned to provide optimal contrast.

3. Materials and Methods

Longitudinal (T1) and transverse (T2) relaxation times of bladder wall, urine, and perivesical fat were estimated for 10 normal subjects and 15 patients that underwent MR examination on a routine clinical 1.0T scanner (Signa Horizon LX; GE Healthcare, Chalfont St. Giles, UK) using the accompanying standard phased-array torso coil.

T1 measurements were performed using a single slice fast spin echo inversion recovery pulse sequence (FSE-IR) [5] with TR: 6000 ms, TE: 16ms, ETL: 12, matrix: 256X192 pixels, FOV: 30X40 cm, slice thickness: 2mm, NEX: 2 and varying inversion times (TI). Initially, T1 maps were calculated using six points in the inversion recovery (6 scans with inversion times in the range from 50 to 4000 ms and a total scan time of ~15 min) and a three-parameter, weighted, robust, non-linear least squares fit utilising a trust region algorithm [6].

This multiparametric six-point fit was used as a guide in order to estimate pairs of best possible inversion times for a two-point T1 measurement method based on signal ratios (total scan time of ~7 min). All T1 measurements were calculated based on the absolute value of the signal, as the clinical scanner used does not provide phase image information and inversion recovery contrast reversal could not be corrected.

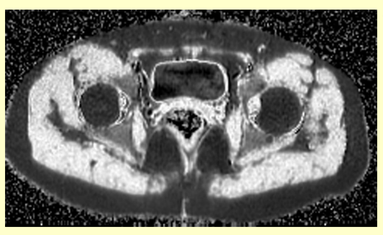
T2 measurements were performed using a 4 echo standard spin echo sequence with TR: 3000 ms, matrix: 256X192 pixels, FOV: 30X40 cm, slice thickness: 2mm, NEX: 2, and TE: 40, 80, 120 and 160 ms.

Multi-point exponential fits and two-point ratio T1 and T2 measurements were performed using software developed in-house.

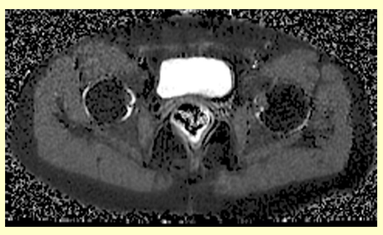
4. Results & Discussion

Optimal pair of inversion times for T1 measurements of short and intermediate T1 components (i.e. bladder wall, muscle and fat) were found to be around 530 ms and 4000 ms, while the optimal pair of inversion times for T1 measurements of long T1 components (i.e. urine) were found to be around 1660 ms and 4000 ms.

T1 maps calculated using the two-point ratio method with the optimal inversion times are shown below.



T1 map for short and intermediate T1 components (<780 ms). Longer T1 components (e.g. urine) are grossly underestimated.



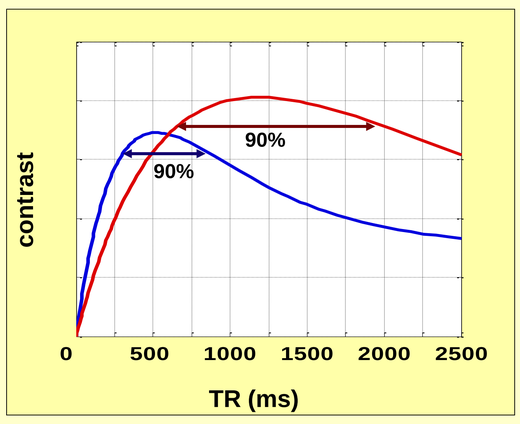
T1 map for long T1 components (>800 ms). Shorter T1 components (e.g. wall and fat) are grossly overestimated.

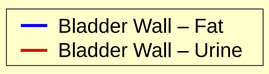
Mean normal inter-subject T1 and T2 values and normalized proton densities are tabulated below:

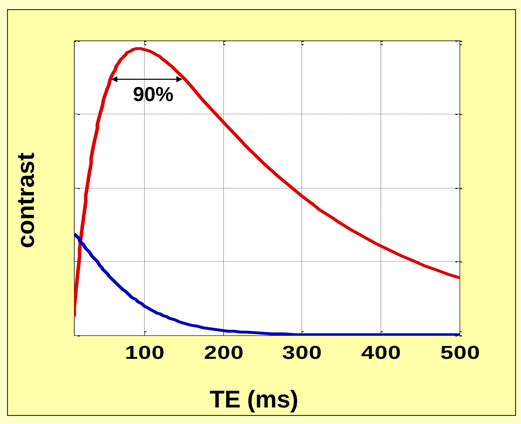
Relaxation Times and Normalized Proton Density of Normal Tissue

	T1 (ms)	T2 (ms)	norm. proton density
bladder wall	**636 ± 44**	**41 ± 5**	**0.85**
perivesical fat	**303 ± 11**	**46 ± 3**	**1**
urine	**2547 ± 62**	**224 ± 10**	**0.84**

Using these mean relaxation time and proton density values, contrast curves for the tissues involved can be calculated for any given pulse sequence. An example is shown in the following graphs for the case of the spin echo experiment.



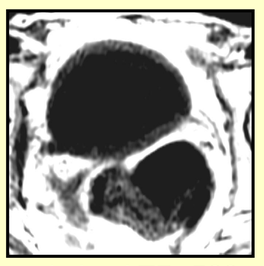




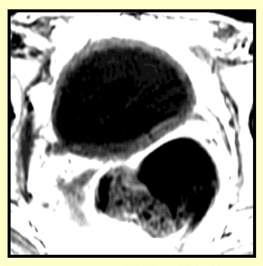
Based on the calculated contrast curves for the representative example of the spin-echo sequence, contrast of bladder wall with regard to urine and perivesical fat is maximized in T1 weighted images.

Although T2 weighted images can also provide good bladder wall – urine contrast, the contrast between bladder and fat is considerably less. The T1 contrast curve indicates that the 90% of maximum achievable contrast between bladder wall and urine can be achieved for repetition times in the range of 695 – 1895 ms, and between bladder wall and perivesical fat for repetition times in the range of 305 – 880 ms. The T2 contrast curve indicates that the 90% of maximum achievable contrast for bladder wall and urine is achieved for echo times in the range of 60 – 135 ms, while between bladder wall and perivesical fat is decreased as the echo time increases.

The following images show a hypertrophic bladder wall (fast spin echo sequence, TE: 14ms, ETL: 2, matrix: 384X256 pixels, FOV: 38X28.5 cm, slice thickness: 6mm, slice spacing: 1mm, and NEX: 3). The thickened bladder can be better depicted in the optimized image (right, TR:780 ms) as opposed to the image produced by the standard clinical scan (left, TR: 520 ms).



unoptimized TR: 520 ms



optimized TR: 780 ms

5. Conclusion

Knowledge of relaxation times in routine clinical imaging can provide information for customized sequence optimization according to each imaging problem. In the case of renal bladder imaging, sequence optimization can maximize the delineation of bladder wall in normal and benign conditions.

5. References

1. Kingsley PB, “Methods of Measuring Spin-Lattice Relaxation Times: An Annotated Bibliography”, Concepts in Magnetic Resonance, 11(4): 243-276, 1999.

2. Bottomley PA, Foster TH, Argersinger RE, Pfeifer LM., “A Review of Normal Tissue Hydrogen NMR Relaxation Times and Relaxation Mechanisms from 1-100 MHz”, Medical Physics, 11(4):425-48, 1984.

3. Fisher MR, Hricak H, Crooks LE, “Urinary Bladder MR Imaging. Part I. Normal and Benign Conditions”, Radiology, 157:467-470, 1985.

4. de Bazelaire CMJ, Duhamel GD, Rofsky NM, Alsop DC, “MR Imaging Relaxation Times of Abdominal and Pelvic Tissues Measured in Vivo at 3.0T: Preliminary Results”, Radiology, 230:652-659, 2004.

5. Gupta RK, Ferretti JA, Becker ED, Weiss GH, “A Modified Fast Inversion-Recovery Technique for Spin-Lattice Relaxation Measurements”, Journal of Magnetic Resonance, 38:447-452, 1980.

6. Coleman TF, Li Y, “An Interior, Trust Region Approach for Nonlinear Minimization Subject to Bounds”, SIAM Journal on Optimization, 6: 418-445, 1996.

ESUR 2005: 12th European Symposium on Urogenital Radiology – Ljubljana, Slovenia, September 8th - 11th 2005

Poster #43