Zonal and age-related differences of prostate spectra at 3 T

J. Weis[1], F. Ortiz-Nieto[1], and H. Ahlström[1]
[1]Uppsala University Hospital, Uppsala, Sweden

Introduction

^{1}H MRS of the prostate is one of the most reliable, minimally invasive approach for distinguishing prostate cancer from benign diseases and healthy tissues [1]. Spectral intensity ratio of choline to citrate (Cho/Cit) and mainly ratio of Cho, polyamines (PA), and creatine (Cr) to Cit (Cho+PA+Cr)/Cit are used as specific markers for the cancer. However, in interpretation of these markers has to be taken into account two facts: (i) concentration of Cit is higher in peripheral zone (PZ) than in the central gland (CG) and (ii) PZ demonstrates significant increasing of the Cit with advancing age and Cit concentration in CG does not change with increasing age. The studies of zonal effects have been mostly performed in 1.5 Tesla. Age dependent effects were reported only in a relatively few studies [2 - 4] (B_0 = 1.5 T) with low number of the healthy volunteers. Main purpose of this work was the quantification of zonal and age dependences of metabolite-to-Cit ratio in 3 T scanner using large number of healthy volunteers.

Materials and Methods

The study included 51 healthy volunteers between 26 and 72 years of age. None had a previous history of genitourinary disease. Prostate specific antigen (PSA) serum levels ranged from 0.4 to 3 ng/ml.

All measurements were performed with a 3 T scanner (Achieva, Philips). MR images and the spectra were acquired with a circular two-element receiver surface coil (loop size 20 cm). Spectra were acquired using 2D MRSI sequence (PRESS, TR/TE 1400/140 ms, spectral BW 2000 Hz, 1024 points, matrix 16×16, FOV = 160 mm, slice thickness 20 mm, 3 acquisitions, circular phase-encoding with reduction factor of 25%). A dual BASING-type pulse [5] was used for water and residual fat suppression. Fat suppression was improved by a frequency-selective inversion recovery pre-pulse. Measured data were zero filled to the size 16×16 and filtered in both phase-encoding directions with a Hanning filter. The net measurement time was 14 minutes and 7 seconds. We used a relatively large nominal voxel size (10×10×20 mm^3 = 2 cm^3) to be able to cover the majority of the prostate within one 2D MRSI measurement and to ensure acceptable SNR. Spectral line fitting and quantification of metabolite-to-citrate peak area ratio was accomplished by LCModel (v. 6.2-1G) [6]. Baseline and phase corrected spectra were normalized by summing the squares of the intensities of each spectral point and then dividing the amplitude of each point by the square root of this sum. Mean spectra were computed by averaging the values at each data point.

Results

311 MRSI spectra (76 %) were evaluated. Exclusion criteria were SNR < 3 and broad spectral lines (poor separation of leftmost and rightmost lines of the Cit quadruplet). Figure 1 shows representative volume of interests (VOI). Mean normalized spectrum and mean LCModel fit of 10 older volunteers (range, 54 – 72 years) are shown in Fig. 2. Figure 3 summarizes differences in metabolite-to-Cit ratio between PZ and CG for age group > 51 years and < 45 years. Correlations of (Cho+PA+Cr)/Cit with the age for PZ and CG are shown in Fig. 4. PZ VOI contained voxels C - F (Fig. 1) with the majority of PZ tissues. CG VOI represent voxels A, B (Fig. 1) with dominated CG tissue. Low correlation (R = -0.39), however, highly significant (P < 0.0001) was found in PZ. No correlation (R = -0.12, P > 0.05) was found in CG tissues.

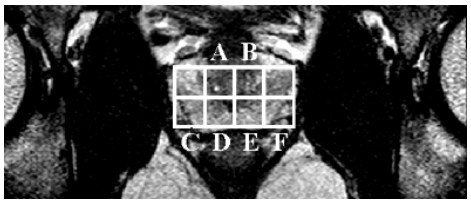

Fig. 1: Transversal T_2-weighted image of the prostate and typical 2D MRSI voxel positions. Nominal voxel size was 10×10×20 mm^3.

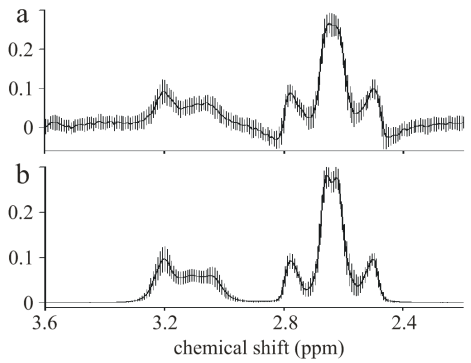

Fig. 2: Normalized mean spectra of healthy prostate (PZ + CG) and standard deviations. 63 spectra of 10 oldest volunteers (age > 54 years) were averaged. (a) Measured spectra, (b) LCModel fits.

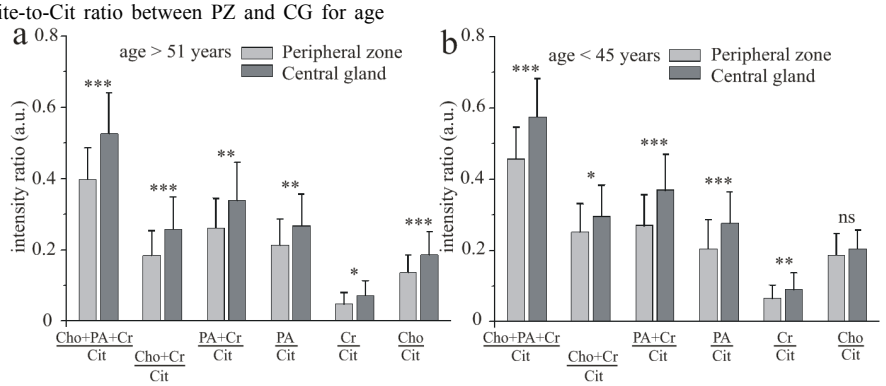

Fig. 3: Metabolite-to-Cit ratio in PZ and CG of (a) 16 older (age > 51 years) and (b) 17 younger (age < 45 years) healthy volunteers. * P < 0.05; ** P < 0.01; *** P < 0.001.

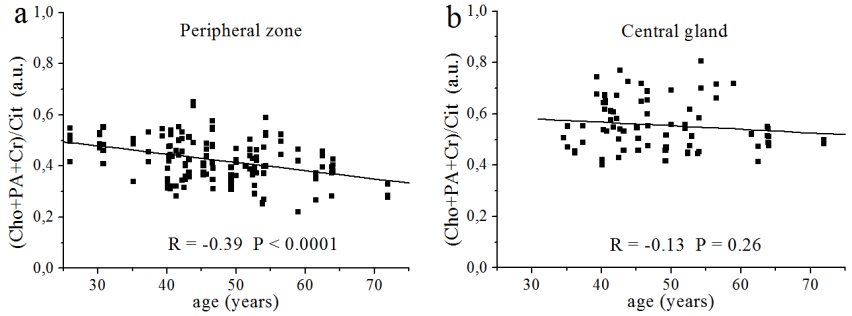

Fig. 4: Correlation of (Cho+PA+Cr)/Cit with the age in (a) PZ and (b) CG tissues.

Discussion

Evaluation of the zonal and age related changes requires a large number of volunteers. This purpose was possible to achieve solely using a surface coil instead of an endorectal coil because this approach was the only acceptable alternative for majority of the healthy volunteers. Significant zonal differences in metabolite-to-Cit ratio (Fig. 3) are obvious in spite of non-negligible contamination of PZ voxels by CG tissue and vice versa (Fig. 1). Voxels with a majority of PZ tissue reveal lower metabolite-to-citrate intensity ratio than CG voxels. Figure 4 confirms previous observations (2, 3) that age related metabolite-to-Cit ratio differences in PZ tissue are caused by decreasing of the Cit concentration with increasing age.

Conclusion

The results of this study demonstrate that zonal differences in metabolite-to-Cit ratio and age dependent changes in PZ are non-negligible and have to be considered in analysis the prostate spectra.

References

[1] Verma S et al, AJR 2010;194:1414-1426. [2] Kurhanewicz et al, Radiology 1996;198:795-805. [3] Lowry M et al, MRM 1996; 36:352-358. [4] Weis et al, ISMRM 2010, #323, [5] Star-Lack J et al, MRM 1997;38:311-321. [6] Provencher SW. MRM 1993; 30:672-679.