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Echo Planar Spectroscopic Imaging with Peak-Enhanced 2D-Capon Analysis for Prostate Studies

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Introduction

Two-dimensional echo planar spectroscopic imaging (EPSI) may be used for clinical evaluation of the human prostate (1,2). The results of EPSI studies are typically represented as the set of magnetic resonance spectroscopy (MRS) absorption spectra that show frequency information of key metabolites. Several nonparametric techniques in addition to Fourier transformation have been proposed for the analysis of MRS data (3,4). In addition to frequency information, the damping characteristics of each metabolite can also be determined by using two-dimensional Capon analysis. This damping information may be used in conjunction with the frequency information to more easily identify metabolites, especially those whose peaks overlap. We propose using peak-enhanced 2D-Capon analysis for spectral analysis of prostate metabolites.

Methods

Data were collected using a 3.0 T General Electric (GE) Signa scanner (GE Healthcare, Waukesha, WI, USA) equipped with a high bandwidth (1.0 MHz) data acquisition subsystem and a TwinSpeed gradient coil capable of 40 mT/m at a maximum slew rate of 150 T/m/s. A prototype EPSI pulse sequence was used with an endo-rectal coil (MEDRAD Inc., Pittsburgh, PA, USA) to collect data from the GE prostate phantom, which contains a solution of known concentrations of metabolites commonly found in the human prostate. The GE prostate phantom contains the following: 50mM potassium phosphate monobasic, 33mM sodium citrate tribasic dihydrate, 4mM choline chloride, 10mM creatine monohydrate, 12 mM lithium l-lactate, 0.1% sodium azide. Conventional single voxel PRESS (PROSE) was also used with the same coil and phantom for comparison purposes. Raw data were saved and reconstructed off-line using MATLAB.

EPSI scan parameters were as follows: 2D, axial, 8x8, TR=1300ms, TE=85ms, field of view = 9cm, voxel thickness = 20mm, 1 NEX, scan time 26 seconds. Scan parameters for single voxel PROSE sequence were: 2D, axial, 1x1, TR=1300ms, TE=85ms, 8cm^3 voxel, 2 NEX, scan time 1 minute and 8 seconds. MATLAB code was used to compute conventional MRS absorption spectra for both single voxel and 2D EPSI scans. In addition, peak-enhanced 2D-Capon analysis(4) was performed on the same data to estimate the relative damping characteristics of each metabolite.

Results

For single voxel PROSE key metabolites such as citrate, choline, creatine and polyamines are easily identified from both Fourier transformation (Fig. 1a) and 2D Capon analysis (Figs. 1b,1c, & 1d) techniques. For the EPSI scan each voxel is much smaller and while water is easily identified using Fourier transformation (Fig. 2a) key metabolites are more difficult to determine. Peak-enhanced 2D-Capon analysis is used on a representative voxel (shown in red in Fig. 2a) to estimate the frequency and damping components of citrate, choline, creatine and polyamines (Figs. 2b, 2c & 2d).

Discussion and Conclusions

Using EPSI for prostate studies can significantly reduce the overall scan time vs. conventional chemical shift imaging (CSI) techniques. Peak-enhanced 2D-Capon analysis techniques can be used to identify the frequency and damping components of key metabolites found in the prostate such as citrate, choline, creatine and polyamines. Projection of the peak-enhanced 2D-Capon results as shown in Fig. 2c can provide improved spectral estimates vs. those obtained by conventional spectral estimation techniques such as Fourier transformation. Furthermore, the additional information about damping characteristics (Figs. 2b & 2d) may be useful for clinical diagnosis.

References

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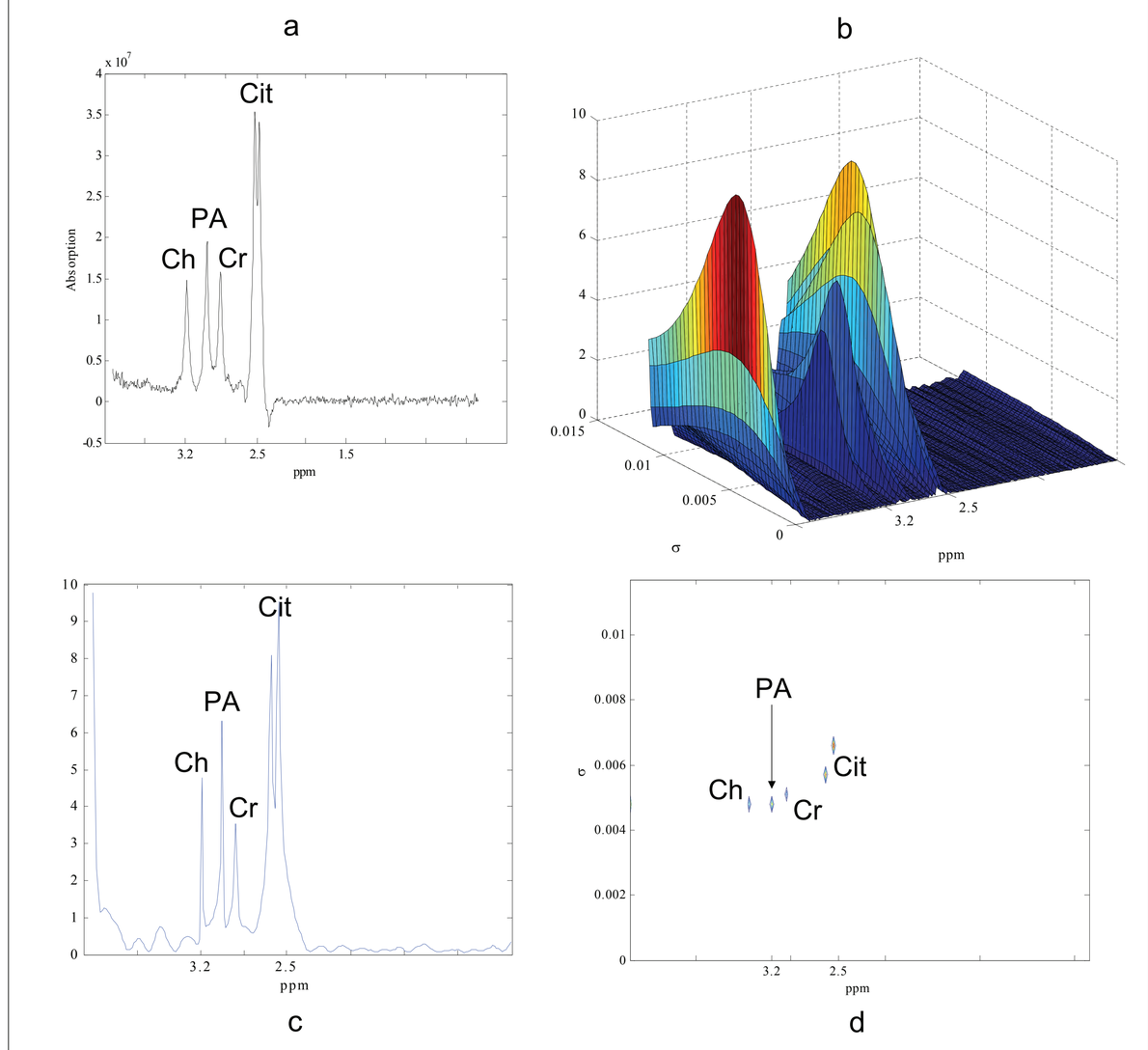

Fig. 1: Results of single voxel PROSE analysis of prostate phantom. a) Fourier b) 2D-Capon c) 2D-Capon projection d) Peak-enhanced 2D-Capon.

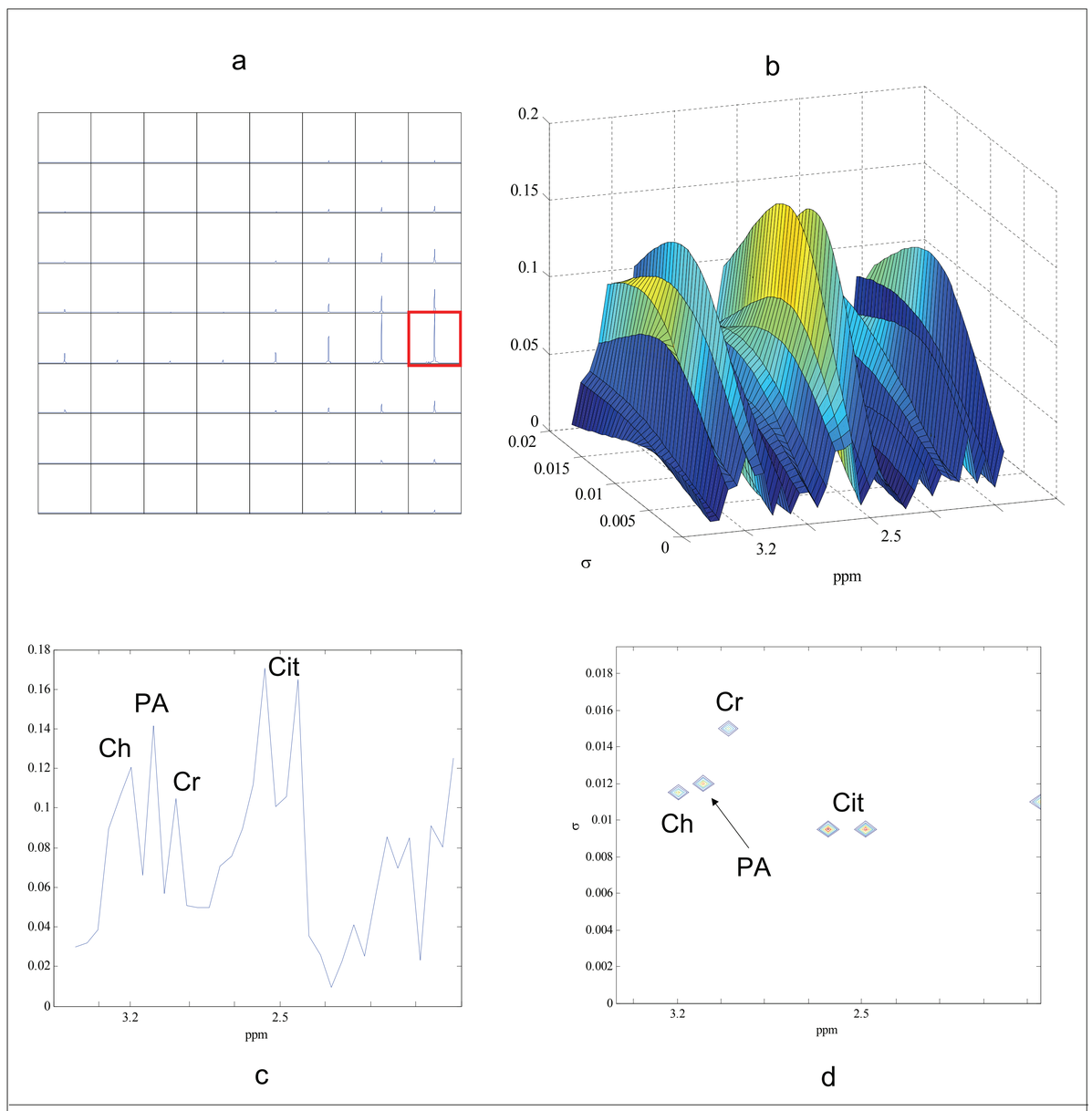

Fig. 2: Results of EPSI PROSE analysis of prostate phantom. a) 2D-Fourier for 8x8 region; b) 2D-Capon of voxel highlighted in red c) 2D-Capon projection of voxel highlighted in red d) Peak-enhanced 2D-Capon of voxel highlighted in red