31P MR Spectroscopy for Prostate Cancer Characterization at 7Tesla

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Introduction: Proton MRS in prostate cancer has shown elevated choline levels in many studies, suggesting altered membrane metabolism. This synthesis may be assessed more accurately with ^{31}P MRS as multiple compounds of this metabolism can be detected with this technique, like phosphoethanolamine (PE), phosphocholine (PC), glycerylphosphorylethanolamine (GPE) and glycerophosphorylcholine (GPC). However the sensitivity of ^{31}P MRS is low and at field strengths like 1.5T these compounds cannot be distinguished due to signal overlaps. At high fields like 7T, both sensitivity and spectral resolution improve. Therefore we explore the use of ^{31}P MRS at 7T in patients with prostate cancer.

Materials/Methods: a 7T MR system (Philips) was used for imaging and spectroscopy measurements. An endorectal coil tuned to 120.6 MHz for ^{31}P MRS in combination with an 8-element surface array for ^{1}H imaging was used for the patient study. Phantom measurements were obtained to check possible RF coupling between all coil elements. B_1^+ phase shimming was performed with the surface array for the prostate area. Image based B_0 shimming was determined by manually selecting the prostate area and using B_0 maps to calculate the optimum B_0 shim currents. A patient with biopsy proven prostate cancer on the inferior area of the prostate with a dorsal extra-capsular extension was examined with this configuration. The endorectal coil was inserted outside the scanner room and the patient was in a supine position. T2 weighted turbo spin echo (TSE) images were obtained for anatomy visualization and tumor location (TR=5.5s, FOV=40x2.7x40cm, 5 slices, scan time 5.1min.). Non-localized (TR=1s, 128 averages) and 3D CSI ^{31}P MRS results were obtained (TR=1s, matrix=8x8x8, FOV=12x12x12cm, 7 averages in the center of k-space with a hamming weighted acquisition, scan time about 24 min.).

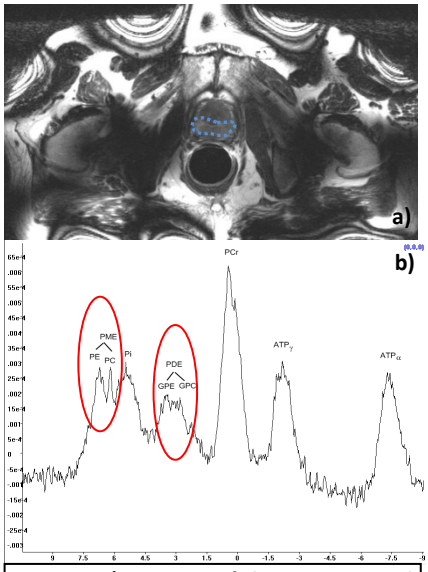

Figure 1: a) T2w TSE of the prostate with highlighted tumor area and b) non-localized ^{31}P spectrum.

Results/Discussion: No RF coupling between the ^{31}P coil and the ^{1}H coil was observed either in phantom or patient measurements. T2 weighted TSE images showed clear depiction of the tumor in the correct location in figure 1a). In the non-localized ^{31}P MR spectrum PC and PE could be resolved of the phosphomonoesters as well as GPE and GPC from the phosphodiesters as shown in the encircle part of the spectrum in figure 1b). In addition, inorganic phosphate (Pi), phosphocreatine (PCr), ATP_γ and ATP_α are also visible as shown in figure 1b). To identify potential contribution of ^{31}P signals coming from areas outside the prostate i.e. muscle tissue, 3D CSI was obtained on the prostate area as shown on figure 2a). Even without adiabatic pulses or with polarization transfer techniques for sensitivity enhancement, localized ^{31}P signals could be obtained from the prostate. Although SNR is low, levels of PE, PC as well as GPE, GPC were found in the tumor location as highlighted in red and green in figure 2b). In addition, Pi peaks can be seen in the third row together with low levels of PCr.

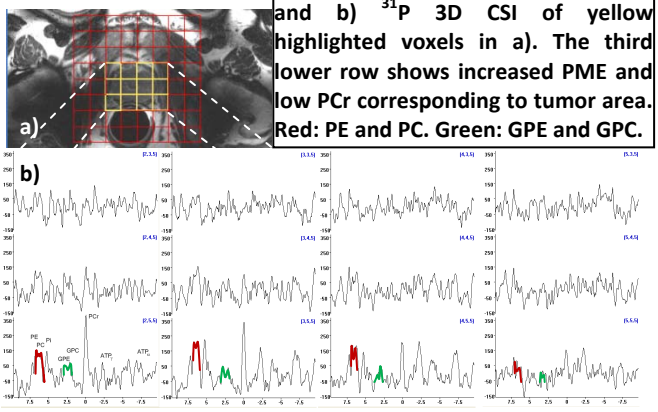

Figure 2: a) T2w-TSE of the prostate and b) ^{31}P 3D CSI of yellow highlighted voxels in a). The third lower row shows increased PME and low PCr corresponding to tumor area. Red: PE and PC. Green: GPE and GPC.

Conclusions: In this study we showed the feasibility of obtaining ^{31}P MRS in the prostate area at 7T with the use of anatomy imaging and optimized B_0 shimming. Individual detection of PC, GPC, GPE and GPC was feasible, illustrating the benefit of high spectral resolutions that can be obtained at field strength of 7T.