Dynamic Contrast-Enhanced MR and Proton MR Spectroscopic Imaging in Localizing Prostate Cancer

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Introduction

The sensitivity of localizing prostate cancer with systematic sextant ultrasound guided biopsy is only 39-52% compared with radical prostatectomy [1, 2]. The sensitivity of this technique is low, due to the fact that more than 40% of prostate cancer lesions are isoechoic and distant central gland tumors. Three MR modalities have been around for some time showing promising possibilities in localizing tumor nodules in patients with prostate cancer:

1.With T2-weighted MR imaging, prostate cancer often appears as an area of low signal intensity in a bright normal peripheral zone. Detecting prostate cancer in the central gland is difficult because this area often contains benign prostate hyperplasia, which has signal intensities similar to that of cancer.

2. Proton MR spectroscopic imaging (MRSI) provides quantitative metabolic data based on the citrate, choline and creatine levels and their ratios. Proton MR spectra of prostate cancer tissue reveal a reduction or depletion of citrate levels and an increased level of choline compared to healthy or benign tissue [3].

3. Dynamic contrast-enhanced MR imaging (DCE-MRI) is reported to be an effective tool in visualizing the pharmacokinetics of gadolinium uptake in the prostate. Prostate cancer has demonstrated different enhancement patterns compared to benign tissue [4].

Using whole mount sections as the reference standard, we prospectively evaluated prostate cancer localization using T2-weighted MR imaging, DCE-MRI and MRSI techniques in the peripheral, transitional and central zone, all applied to the same patient.

Materials and methods

34 consecutive patients with biopsy-proven prostate cancer underwent the following endorectal coil MR examinations prior to radical prostatectomy on a 1.5T Magnetom Sonata system (Siemens Medical Solutions, Erlangen, Germany): First, multi-slice T2-weighted multiple spin echo images were obtained with a resolution of 0.55 x 0.55 x 4 mm^3 (TR 3500-4400 ms/ TE 132 ms) in three orthogonal planes of the prostate and seminal vesicles. Second, 3D ^{1}H-MRSI (PRESS) of the whole prostate was performed with a nominal voxel size before apodization of 6 x 6 x 6 mm^3 (TR 650 ms / TE 120 ms; Hamming weighted signal averaging ref scheenen). Third, 60 3D volumes of T1-weighted spoiled gradient echo images with resolution 1.1 x 1.1 x 4.0 mm^3 (TR 34ms/TE 1.6 ms; flip angle 14°; 10 axial partitions in 3D slab) were acquired with a temporal resolution of 2 seconds during a bolus injection of Gd-DTPA (Magnevist®; Schering, Berlin, Germany).

From MRSI the quantitative measure of choline + creatine to citrate (CC/C) ratio was determined; DCE-MRI was first reduced to a five-parameter signal-enhancement curve (including washout) and converted into a reduced tracer concentration-time curve using the reference tissue method [5]. K_{ep}, K_{trans} and v_e were then calculated from this reduced curve. All prostates were divided into 14 ROIs (4 in apex, 6 in midgland and 4 in base of prostate) and in these ROIs two readers independently and randomly scored T2-weighted imaging, the quantitative CC/C ratio of MRSI, K_{ep}, K_{trans}, v_e and washout from DCE-MRI for the presence of prostate cancer on a 1-5 scale. The ROIs were compared to the histopathological analysis by the two radiologists in consensus after evaluation (1 month) of the data

Results

A typical example of a complete dataset of a patient is presented in Figure 1. The overall accuracy of localizing prostate cancer using T2-weighted MR images was 69% (328/476) and 67% (317/476), for reader A and B, respectively. The overall localization accuracy using MRSI was 79% (305/384) and 79% (289/366) for reader A and B, respectively. The DCE-MRI studies read in conjunction with the T2-weighted MR images resulted in a localization accuracy of 81-91%. K_{trans} and v_e performed significantly better than T2-weighted MR images ($P < 0.01$). The localization accuracy increased significantly ($P < 0.05$) using MRSI compared to T2-weighted MR images for both readers. A statistically significant greater area under the curve (Az) was present using K_{trans} and v_e (Az = 0.85 and 0.87, respectively) compared with MRSI (Az = 0.80; $P < 0.01$). Both DCE-MRI and MRSI were significantly better in tumor localization than reading T2-weighted imaging (Az = 0.68).

Discussion and conclusions

This study demonstrates that using either DCE-MRI or MRSI in localizing prostate cancer significantly improves performance compared to T2-weighted MR imaging. There are several differences between both functional imaging techniques in this evaluation. The MRSI spectra were analyzed using a quantitative approach, which is basically independent from prior knowledge on the presence of tumor in the prostate and the MR image, which is used as background to the metabolic information. The DCE-MRI data were read in a subjective way in this study. This method was chosen because in literature different approaches have been used in the analysis of DCE-MRI data and absolute values of DCE-MRI parameters may be rather variable among patients Our results suggest that if these advanced MR imaging techniques are included in the MR imaging protocol the localization in prostate cancer patients will improve.

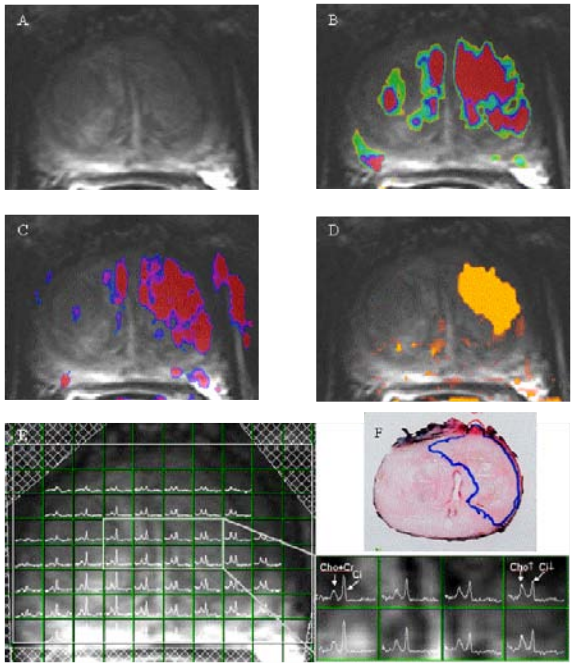

Figure 1. Data example of a 71-year-old prostate cancer patient (PSA = 16.4 ng/ml; Gleason sum 6). (A) Axial T2-weighted MR image of the prostate. (B) to (D) Pharmacokinetic maps of calculated parameters: K^{trans} (B) k_{ep} (C) and washout (D). (E) Spectral map with the spectra of 8 voxels outlined in detail.. (F) Whole-mount section histopathology of the slice at a corresponding level.

References:

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