Dynamic contrast-enhanced analysis of the prostate at 3T with a body array coil is feasible and increases prostate cancer localization performance.

S. W. Heijmink[1], J. J. Fütterer[1], P. C. Vos[1], T. W. Scheenen[1], H. J. Huisman[1], C. A. Hulsbergen-v.d. Kaa[2], J. A. Witjes[3], J. O. Barentsz[1]

[1]Radiology, Radboud University Nijmegen Medical Center, Nijmegen, Gelderland, Netherlands, [2]Pathology, Radboud University Nijmegen Medical Center, Nijmegen, Gelderland, Netherlands, [3]Urology, Radboud University Nijmegen Medical Center, Nijmegen, Gelderland, Netherlands

Introduction

With a predicted 230,090 new cases of prostate cancer for the year 2005 in the United States alone, the disease burden is considerable (**1**). The majority of papers published on magnetic resonance (MR) imaging of prostate cancer at 1.5 tesla (T) have used an endorectal coil in order to obtain sufficiently high resolution for cancer localization and staging. Prostate imaging at higher field strengths (e.g. 3T) may provide sufficient spatiotemporal resolution with use of the body array coil (BAC) as sole receptor coil array. This could potentially spread the use of MR imaging in prostate cancer patients. Therefore, the purpose of this study was to determine the feasibility of high temporal dynamic contrast-enhanced (DCE) MR imaging at 3T with solely a BAC. Furthermore, the diagnostic performance of DCE MR imaging was compared with that of T2-weighted imaging for localizing prostate cancer.

Materials and methods

After written informed consent, 17 consecutive patients with biopsy-proven prostate cancer underwent an MR imaging examination with an eight-element BAC on a 3T whole-body system (Magnetom TRIO, Siemens Medical Solutions, Erlangen, Germany) prior to radical prostatectomy. Directly before the examination the patients received a 1 mg intramuscular injection of glucagon (Glucagen®, Novo Nordisk A/S, Denmark) to suppress bowel motion. No further bowel preparation was performed. T2-weighted imaging in three directions was performed (parameters: TR/TE 3700/124 msec; FOV: 220x100 mm; slice thickness: 4 mm; matrix: 512x512; variable flip angle; voxel size: 0.43x0.43x4.00 mm^3; one average; acquisition time: 4.57 minutes). Subsequently, a proton density sequence was performed for calibration of the DCE series (parameters: TR/TE 800/1.48 msec; FOV: 200x100 mm; slice thickness: 4 mm; matrix: 128x64; one average; acquisition time: 0.43 minutes). A three-dimensional T1-weighted gradient echo series (parameters: TR/TE 34/1.48 msec; FOV: 200x100 mm; partition thickness: 4 mm; matrix: 128x64x10; 70 acquisitions; acquisition time: 2.05 minutes) was obtained during administration of 0.1 mmol/kg bodyweight gadoterate meglumine (Dotarem®, Guerbet, Aulnay-sous-Bois, France) at a rate of 2.5 ml/sec followed by a saline flush. The signal enhancement-time curves were reduced to five-parameter models (**2**) and converted to reduced tracer concentration [mmol/ml] - time curves (**3**). Plasma input function was estimated using the reference tissue method (**4**). From these curves the parameter estimates for extracellular volume (v_e), volume transfer constant (K^{trans}), rate constant (kep) (**5**) and latewash were calculated. These parametric data were semitransparently overlaid on top of the T2-weighted images. Two radiologists read all anonymized T2-weighted and DCE MR images in separate sessions. They scored all sets for image quality and presence of motion artifacts. The order in which the DCE MR imaging parameters were read was randomized. The radiologists scored the presence of cancer in a 16-segment model of the whole prostate on a five point probability scale. Subsequently, the scores for both radiologists were pooled. A single experienced pathologist who was blinded to the MR imaging results outlined the presence and extent of cancer on all radical prostatectomy specimens. The 16 segments were regarded as regions of interest and a region of interest ROC analysis was performed (**6,7**). Areas under the receiver operating characteristic curves (Az) were determined for T2-weighted imaging and for each DCE parameter, as well as for the combination of all dynamic parameters, the mean pharmacokinetic score (MPKS) which was constructed by computing the mean of the pharmacokinetic parameters scores of the readers' conditionally independent observations. $P<0.05$ was considered statistically significant.

Results

Image quality of both the T2-weighted and DCE MR imaging was sufficient or excellent in all patients. The Az for localization with T2-weighted imaging was 0.60. For the DCE parameters v_e, K^{trans}, kep and latewash the Az were 0.65, 0.68, 0.67 and 0.60, respectively. The Az for the MPKS was 0.72. The difference between the MPKS and the T2-weighted imaging was statistically significant (Figure 1, $p<0.05$). An example of the increased localization performance by means of DCE MR imaging with solely a BAC is shown in Figure 2.

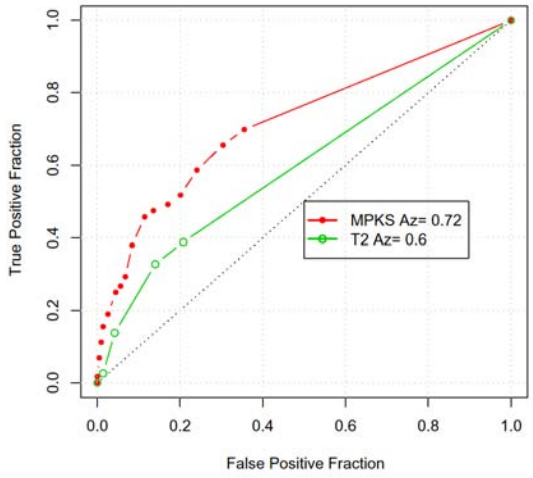

Figure 1. Region of interest receiver operating characteristic (ROC) curves and areas under the ROC curves using the regions of interest ROC analysis for localizing prostate cancer with T2-weighted imaging and combining all DCE parameters. The difference was statistically significant ($p<0.05$).

Discussion and conclusions

DCE MR imaging with solely a BAC is feasible and the quality was sufficient to excellent in all patients. By combining the DCE parameters the localization performance of prostate cancer was improved significantly compared with T2-weighted imaging using a BAC at 3T. Thus application of contrast agent can enhance localization performance when performing BAC MR imaging at 3T.

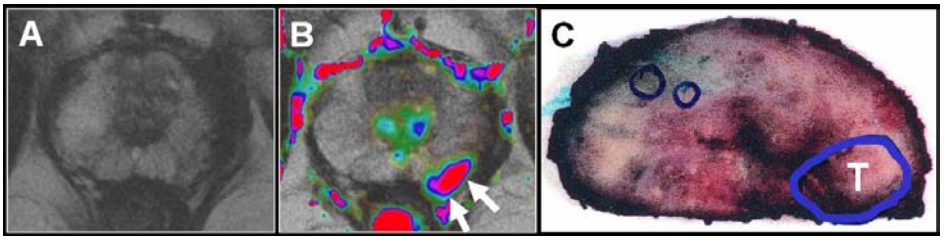

Figure 2. An example of the increased localization performance with dynamic contrast-enhanced MR imaging. (A) On the T2-weighted images no clear lesion was detected. (B) The kep parameter revealed a lesion (arrow) in the left peripheral zone. (C) Whole-mount section histopathology confirmed the presence of the cancer focus (T) with a Gleason score of 4+4.

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