MR Imaging in the Evaluation of Microwave Treatment of the Prostate

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Introduction

Symptomatic chronic urine retention due to benign hyperplasia of the prostate (BHP) is not uncommon in older men. Until recently, therapeutic options were permanent urinary bladder catheter (which can lead to chronic urinary infections) or preferably operative prostatectomy (with low but definitive risks for peri- and postoperative complications). Recently, minimally invasive transurethral microwave thermotherapy (TUMT) of the prostate was introduced to relieve the patient's infravesical obstruction by producing coagulation necrosis. However, the clinical results showed a large variability mainly attributed to the different tissue composition and blood perfusion of the prostate in each individual patient, which influence the absorption of the microwave energy and the dispersion of the heat inside the prostate. Identification of specific parameters able to predict favorable therapeutic response would be highly desirable. The goal of our study was to assess morphological and structural features of the hyperplastic prostate with MR imaging before and after TUMT and to determine their influence on the treatment.

Methods

In this prospective study, 11 patients with chronic urinary retention due to BPH were so far included. Inclusion criteria were the size of the prostate > 30 ml [determined by transrectal ultrasound (US) (Bruel & Kjaer, UA 1082®, Denmark)] and the minimal duration of urine retention of one month with at least one catheter attempt. The mean age of the patients was 70.2 ± 5.2 years. All patients underwent also urodynamic investigation (Uro Dyn UD2000, Urodynamic system, MMS, The Netherlands) before and 6 months after the treatment. The patients were treated with Coretherm (ProstaLund, Lund, Sweden) microwave thermotherapy with the set goal to create a 30 % necrosis of the prostate. This device had a temperature probe with 3 integral sensors that continuously measured the intraprostatic temperature and calculated the accumulated amount of necrosis (cell-kill).

The patients were examined with MR imaging before (n = 11), 1 week (n = 10), and 6 months after thermotherapy (n = 7). MR imaging was performed on a 1.5-T whole body system (Intera, Philips Medical Systems, NL) using a 5-element phased array coil for examination of the prostate. After initial scans for planning and preparation, high-quality sagittal T2-w. TSE (TR/TE = 4742/130 ms, voxel size = 0.35/0.35/3.0 mm^3, turbo factor = 18), sagittal T2-w. TSE for T2 calculation (TR/TE = 3000/15-90, voxel size = 1/1/6 mm^3, turbo factor = 6), transverse T2-diffusionw. SE-EPI with 5 b-factors (max b-factor 700, TR/TE = 2072/94 ms, voxel size = 1/1/5 mm^3, EPI factor = 79), and sagittal dynamic 3D T1-w. fast field echo (TR/TE = 5.1/2.5 ms, voxel size = 1.2/1.2/3.0 mm^3, turbo factor = 20) sequences before and under intravenous gadolinium bolus injection (0.2 mmol gadolinium/kg body weight, immediately followed by a 30 ml NaCl flush; flow = 5 ml/s) were obtained.

Data analysis

MR images were analysed at a workstation (Gyroview, Philips Medical Systems, NL). Volume, T2, ADC, and perfusion (mean upslope [signal intensity/s]) of the prostate were calculated. The applied energy, duration, and mean effect of the TUMT were noted. The perfusion defect in the prostate after TUMT was measured. These parameters were correlated with the different MR imaging and tissue parameters. Resumption of the ability to void spontaneously was considered as therapeutic success. The clinical outcome was further described with the International Prostate Symptom Score (IPSS, 0 – 35), Quality of Life score (QoL 0 – 6) and peak urinary flow (Qmax). All values are given as mean ± SD. A p-value of ≤ 0,05 was considered statistically significant.

Results

All MR examinations could be performed with good diagnostic image quality. There was underestimation of the prostate volume with US (73.1 ± 29.7 cm^3) compared to MR (91.6 ± 29.8 cm^3), r = 0.89 (p = 0.001). The mean values of the T2, ADC and mean upslope of the prostate before thermotherapy were 111.9 ± 21.0 ms, 1.76 ± 0.27 x 10^{-3} mm^2/s, and 34.7 ± 10.2, respectively. The mean treatment time was 38.6 (range 21 – 70) min with a mean applied energy of 133.2 (range 61 – 253) kJ and mean effect of 59.9 (range 44 - 67) W. The T2-value of the prostate before TUMT correlated significantly with the prostate volume (r = 0.93, p <0.0001) and the perfusion defect after thermotherapy (r = 0.84, r = 0.003), but not with the applied energy (r = 0.60, P = 0.088), duration (r = 0.58, p = 0.109), or mean effect (r = 0.45, p = 0.239) under the TUMT. The ADC before TUMT correlated significantly with the prostate volume (r = -0.67, p = 0.046), applied energy (r = -0,87, p = 0.001), duration (r = -0.79, p = 0.008), and mean effect (r = -0.75, p = 0.017) during the TUMT, but not with the perfusion defect (r = -0.54, p = 0.139) after the TUMT. The mean upslope of the perfusion of the prostate showed no significant correlation with neither the prostate volume, energy, duration, mean effect of the TUMT nor the posttherapeutic perfusion defect (r = - 0.17 – 0.31, p = 0.43 – 0.67). The under the TUMT calculated cell-kill (73.1 ± 7.5 g) corresponded to 29 % of the prostate volume and correlated significantly with the resulted perfusion defect (23.6 ± 12.6 cm^3) 1 week after TUMT which corresponded to 32 % of the prostate volume (r = 0.79, p = 0.005). So far 7 patients completed the 6 months' follow-up with the TUMT as monotherapy whereas 1 patient had to be retreated operatively because of subjective dissatisfaction. All 7 patients were able to void spontaneously (Qmax = 15.1 ± 8.4 ml/s) and had a cavity in the prostate with a volume of 7.6 ± 7.1 cm^3. In addition, there was change of the prostate volume from before TUMT (91.6 ± 29.8 cm^3) to 1 week (98.9 ± 35.5 cm^3, + 9 %) and 6 months (77.6 ± 33.1 cm^3, - 15 %), after TUMT. IPSS and QoL at 6 months' follow-up were 12.7 ± 9.7 and 2.1 ± 1.8, respectively.

Conclusions

Coretherm microwave treatment seems to be an effective therapy in patients with chronic urinary retention due to BPH. The thermotherapy leads to intraprostatic necrosis, detectable with MR imaging even 6 months after the treatment. Our preliminary results suggest that T2- and diffusion-w. MR imaging may be used to characterize the prostate and predict the response of the prostate during and after thermotherapy.