Int Urol Nephrol
DOI 10.1007/s11255-011-9944-7

UROLOGY – ORIGINAL PAPER

Effects of pulsed electromagnetic fields on benign prostate hyperplasia

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Received: 27 January 2011 / Accepted: 19 February 2011

Abstract
Introduction Benign prostate hyperplasia (BPH) has been treated with various types of electromagnetic radiation methods such as transurethral needle ablation (TUNA), interstitial laser therapy (ILC), holmium laser resection (HoLRP). In the present study, the effects of a noninvasive method based on the exposure of patients with BPH to a pulsative EM Field at radiofrequencies have been investigated.
Materials and methods Twenty patients with BPH, aging 68–78 years old (y.o), were enrolled in the study. Patients were randomly divided into two groups: the treatment group (10 patients, 74.0 ± 5.7 y.o) treated with the α-blocker Alfusosin, 10 mg/24 h for at least 4 weeks, and the electromagnetic group (10 patients, 73.7 ± 6.3 y.o) exposed for 2 weeks in a very short wave duration, pulsed electromagnetic field at radiofrequencies generated by an ion magnetic inductor, for 30 min daily, 5 consecutive days per week. Patients of both groups were evaluated before and after drug and EMF treatment by values of total PSA and prostatic PSA fraction, acid phosphate, U/S estimation of prostate volume and urine residue, urodynamic estimation of urine flow rate, and International Prostate Symptom Score (IPSS).
Results There was a statistically significant decrease before and after treatment of IPSS ($P < 0.02$), U/S prostate volume ($P < 0.05$), and urine residue ($P < 0.05$), as well as of mean urine flow rate ($P < 0.05$) in patients of the electromagnetic group, in contrast to the treatment group who had only improved IPSS ($P < 0.05$). There was also a significant improvement in clinical symptoms in patients of the electromagnetic group. Follow-up of the patients of this group for one year revealed that results obtained by EMFs treatment are still remaining.
Conclusion Pulsed electromagnetic field at radiofrequencies may benefit patients with benign prostate hyperplasia treated by a non-invasive method.

Keywords Pulsed EMFs · Prostate hyperplasia · IPSS · α-blocker

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Introduction

The effects of the electromagnetic fields (EMFs) on living organisms have been extensively studied in the last decades [1]. EMFs are considered to induce alterations in the cell proliferation rates, changes in

Published online: 03 May 2011

mRNA and protein synthesis, alterations in cellular membrane permeability and Ca^{2+}, Na^{+}, K^{+} ion transfer, and alterations in the rates of apoptosis [2–4]. Occupational and environmental exposure to EMFs may also increase prostate cancer mortality [5] or enhance growth rates of prostate cancer spheroids [6]. Radiofrequency and other EMFs have however been used for the treatment of various experimental pathologies [7–9].

Benign prostate hyperplasia (BPH) is a common problem in the elderly men, which has been treated with various types of electromagnetic radiation minimal invasion methods such as transurethral needle ablation (TUNA), interstitial laser therapy (ILC), and holmium laser resection (HoLRP), which exert thermal effects on prostate [10–14].

In the present study, the effects of a noninvasive method by exposure of patients with BPH to a radiofrequency-pulsed electromagnetic field inducing nonthermal effects are reported.

Materials and methods

Twenty patients with BPH, aging 68–78 y.o, were enrolled in the study. Patients' criteria of acceptance in the study include low values of PSA (<4), no signs of prostate cancer in prostate ultrasound examination, and FNA pathology. The participation of the volunteers in the study was without monetary compensation and in agreement with the human rights legislation from the Declaration of Helsinki (1979).

Patients were randomly divided into two groups: the treatment group (TG), consisted of 10 patients, 74.0 ± 5.7 y.o, treated with the α-blocker Alfusosin, of 10 mg/24 h for at least 4 weeks, and the electromagnetic group (EG), consisted of 10 patients, 73.7 ± 6.3 y.o, exposed to a pulsed electromagnetic field at radiofrequencies generated by the PAPIMI device, for 30 min/day for 10 consecutive days in a two-week period. After this period, estimation of patients of both groups was performed. Also, patients of both groups were followed up for one year.

Patients of both groups were submitted to blood and biochemical tests, as well as to estimation of acid phosphatase (AP), total and prostate fraction of PSA, U/S estimation of the prostate volume and urine residue after micturation, urodynamic estimation of urine flow rate, and International Prostate Symptom Score (IPSS) before and after treatment [15].

The Ion Magnetic Inductor, (PAPIMI® device, model 600 Pulse Dynamics Athens, Greece) was used for the electromagnetic treatment of the patients. According to manufacturer, the device produces electromagnetic pulses with the following characteristics: 35–80 J/pulse for energy, 1×10^{-6} s for wave duration, $35–80 \times 10^{-6}$ W for wave power, amplitude of the order of 12.5 mT, rise time 0.1 μs, fall time 10 μs, and repetitive frequency of 3–8 Hz.

The antenna loop of this device (30 × 15 cm, one winding with two turns), which produces a short-duration bipolar PEMF, was horizontally centered over the pubic area and under the perineum of the patients at a maximum distance of 5 cm from the skin. Patients were exposed for 15 min in each of the areas (total 30 min) to the PAPIMI device pulses at a frequency of 750 kHz and at a rate of 4 pulses per second (pps).

Results

Blood tests and biochemistry were found within normal limits before and after treatment in all patients of both groups. There was no significant alteration in PSA values in none of the patients. Patients of the TG showed a significant decrease in IPSS after treatment ($P = 0.04$), but no significant decrease in any other of the parameters was recorded (Table 1). Decrease of IPSS score in patients treated with α-blockers was mainly due to the improvement of frequency, urgency, and nocturia. In contrast, patients of the EG manifested a statistically significant decrease in all parameters studied, such as prostate volume, urine residue, mean urine flow rate, and IPSS (Table 2; Figs. 1, 2, and 3).

There was also a remarkable improvement in symptoms of BPH in the patients of the EG. The PEMFs-treated group was restudied with IPSS score

Table 1 Treatment group ($N = 10$)

	Before	After	P
PSA (ng/ml)	1.2 ± 0.3	1.4 ± 0.5	=0.58
IPSS	19 ± 2	16 ± 4	=0.04
U/S prostate volume (cm^3)	40 ± 10	39 ± 10.5	>0.05
U/S urine residue (cm^3)	110 ± 30	105 ± 20	>0.05
Mean urine flow rate (ml/sec)	8 ± 1	8.1 ± 2	>0.05

PSA Prostate-specific antigen, *IPSS* The International Prostate Symptom Score, *U/S* ultrasound

Table 2 Electromagnetic group ($N = 10$)

	Before	After	*P*
PSA (ng/ml)	0.7 ± 0.2	0.6 ± 0.2	=0.7
IPSS	20 ± 2	14 ± 3	<0.02
U/S prostate volume (cm^3)	33 ± 5	30 ± 2	<0.04
U/S urine residue (cm^3)	100 ± 40	70 ± 25	<0.03
Mean urine flow rate (ml/sec)	8 ± 0.5	11 ± 0.2	<0.001

PSA Prostate-specific antigen, *IPSS*, The International Prostate Symptom Score, *U/S* ultrasound

and U/S of prostate, and they all maintained the scores achieved after EMFs treatment. In contrast, all patients treated with α-blockers were submitted to prostatectomy within 30 days after a four-week treatment with α-blockers because of deterioration of their symptoms and no alteration in prostate volume. All patients of the TG were subjected to prostatectomy within 30 days after the end of the study in contrast to none of the EG patients, who remained clinically improved and almost free of symptoms for more than a year after exposure to the above pulsed electromagnetic field.

Discussion

In the present study, the effects of a pulsed electromagnetic field on patients suffering from benign prostate hyperplasia are reported. According to our results, patients exposed to the pulsed

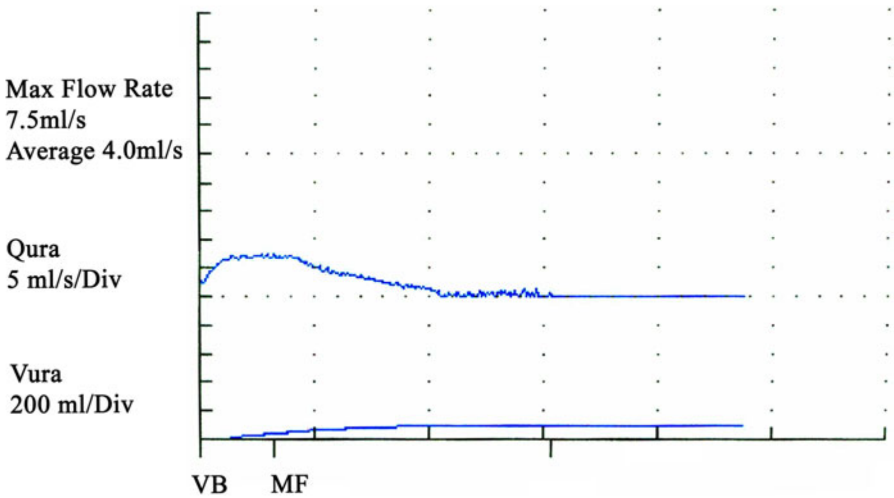

Fig. 1 U/S (ultrasound) of prostate in a patient belonging to electromagnetic group (EG) before and after the EMFs treatment

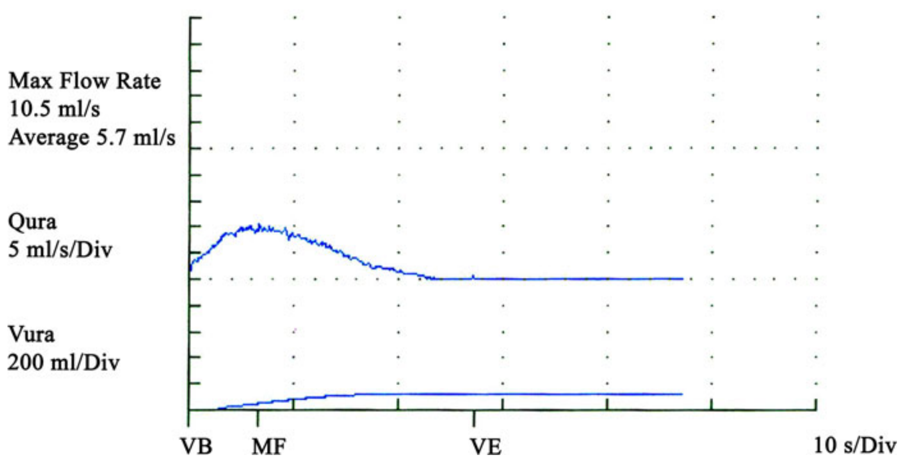

Fig. 2 Urodynamic test in a patient of the electromagnetic group (EG) before and after the EMFs treatment

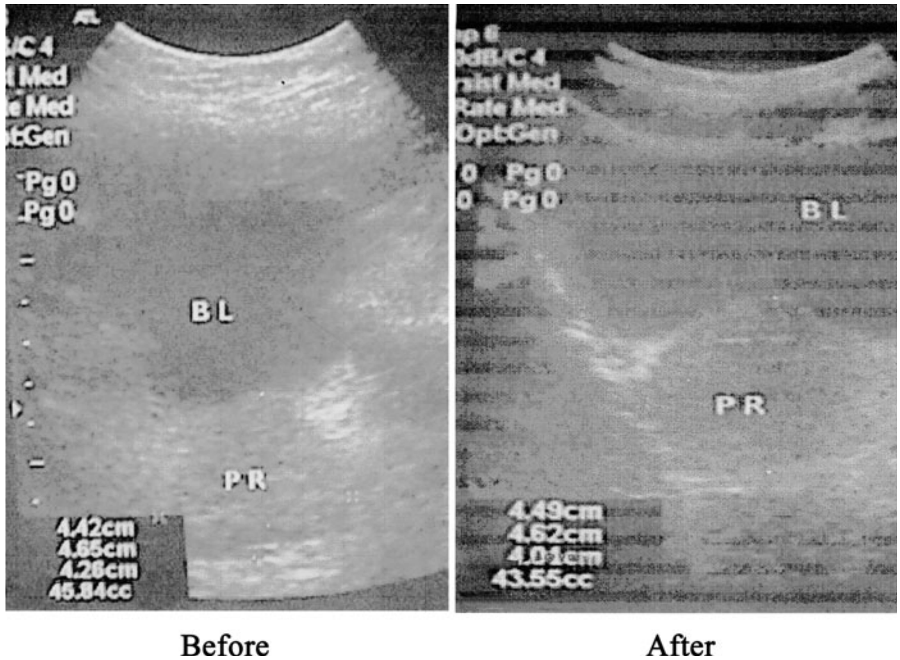

Fig. 3 U/S (ultrasound) of prostate in a patient before and after treatment with PEMFs

electromagnetic field at radiofrequencies manifested a significant improvement of prostate hyperplasia symptoms as determined by the IPSS, as well as a statistically significant reduction in prostate volume, urine residue volume, and significant improvement in mean urine flow rate, compared with the TG patients treated with α-blockers ($P < 0.05$). Furthermore, all patients treated with the electromagnetic field remained improved for more than one year in contrast to the patients treated with α-blocker, who subjected to prostatectomy within one month after treatment. Since our patients treated with PEMFs had a rather small size of prostates, we cannot predict whether the PEMFs will affect patients with larger prostates. Nevertheless, we can suppose that for such patients, PEMFs treatment may have beneficial effects with longer time of daily exposure and longer duration of treatment. According to our knowledge, this is the first study dealing with the effects of pulsed electromagnetic fields on benign prostate hyperplasia.

Exposure to low-intensity radiofrequencies as those used in the present study has been proven to cause no thermal effects in the tissues or cells and seems safe in contrast to environmental or occupational exposure in electromagnetic fields that may cause harmful effects in living organisms. Dealing with prostate lesions, occupational and/or environmental exposure to EMFs may increase prostate cancer mortality [5] or enhance growth rates of prostate cancer spheroids [6]. Pulse rate of EMFs seems to be a significant parameter regulating their effects on cells [1]. Unpublished data of ours indicate that pulsed EMFs as those generated by the PAPIMI device may induce either enhancement or reduction in the proliferation rate on prostate cancer cells depending on the pulse rate (pps) of the field. Pulse rates above 6 pulses per second (pps) induced a significant increase, whereas less than 4 (pps) induced a significant decrease in the proliferation rate of prostate cancer cells ($P < 0.05$). Similar effects have also been found on wound healing effects of radiofrequencies generated by the PAPIMI device [8]. According to this finding, the rate of 4 pulses per second (pps) to expose BPH patients was chosen.

Studies on the magnetic fields of prostate revealed that prostate cancer emits higher biomagnetic activity than BPH as measured by superconducting quantum interference device (SQUID) [16]. Furthermore, the nonlinear resonance radiofrequencies of prostate with various lesions revealed different electromagnetic properties between malignant, hyperplastic, and normal prostatic tissue, which can be used for the diagnosis of prostate cancer [17].

Frequencies emitted by the device used are in the band of radiofrequencies and possibly resonate with the abnormal prostate tissue. Resonance frequencies have been shown to exert beneficial effects on various human pathologies [7, 18].

There are data indicating that oscillating electromagnetic fields may modify the influx or efflux of various ions such as Na^+, K^+, Ca^{2+}, and others through the cellular membrane by inducing an irregular gating of ion channels and that upset the electrochemical balance of the plasma membrane and consequently the whole cell function [19, 20]. Ca^{2+} intracellular signaling may induce alterations in the expression of various genes as well as apoptosis of abnormal cells [21]. EMFs may increase intracellular Ca^{2+} concentrations in various types of cells [22, 23] inducing thus apoptosis also on prostate cancer cells [24]. Radiofrequency fields have been shown to exert apoptotic effects on malignant cell lines [2–4]. According to the above, apoptosis of hyperplastic prostate cells induced by the PEMFs could explain our effects on BPH.

Benign prostate hyperplasia is now considered as an immune-inflammatory disease in which IL-15, INF-γ, proinflammatory cytokines, and T-lymphocytes (CD4 +) are involved [25]. Pulsed and static EMFs may exert anti-inflammatory effects [26], affecting thus the inflammatory process in BPH. Pulsed electromagnetic fields generated by the ion magnetic inductor (PAPIMI-300) have been shown to relieve pelvic pain of gynecological origin in humans [27] and treat refractory seizures due to a cerebral benign mass in one epileptic woman [28].

In conclusion, exposure of patients to pulsed, short wave duration EMFs at radiofrequencies seems to exert beneficial effects on BPH. Further studies are probably needed in order to elucidate the exact mechanism through which certain pulsed EMFs induce their effect on benign prostate hyperplasia and introduce it as a noninvasive method in the treatment of prostate lesions.

Acknowledgments We thank Dr. P. Pappas for his kind donation of the Ion Magnetic Inductor device and for his technical advices.

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