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# Effects of pulsed electromagnetic fields on benign prostate hyperplasia

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## 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,  $74.0 \pm 5.7$  y.o) treated with the  $\alpha$ -blocker Alfusosin, 10 mg/24 h for at least 4 weeks, and the electromagnetic group (10 patients,  $73.7 \pm 6.3$  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.

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**Keywords** Pulsed EMFs · Prostate hyperplasia ·  
IPSS ·  $\alpha$ -blocker

## 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

mRNA and protein synthesis, alterations in cellular membrane permeability and  $\text{Ca}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$  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,  $74.0 \pm 5.7$  y.o, treated with the  $\alpha$ -blocker Alfusosin, of 10 mg/24 h for at least 4 weeks, and the electromagnetic group (EG), consisted of 10 patients,  $73.7 \pm 6.3$  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<sup>®</sup> 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,  $1 \times 10^{-6}$  s for wave duration,  $35\text{--}80 \times 10^{-6}$  W for wave power, amplitude of the order of 12.5 mT, rise time 0.1  $\mu\text{s}$ , fall time 10  $\mu\text{s}$ , and repetitive frequency of 3–8 Hz.

The antenna loop of this device ( $30 \times 15$  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  $\alpha$ -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         | <i>P</i> |
|---------------------------------------|---------------|---------------|----------|
| PSA (ng/ml)                           | $1.2 \pm 0.3$ | $1.4 \pm 0.5$ | $=0.58$  |
| IPSS                                  | $19 \pm 2$    | $16 \pm 4$    | $=0.04$  |
| U/S prostate volume ( $\text{cm}^3$ ) | $40 \pm 10$   | $39 \pm 10.5$ | $>0.05$  |
| U/S urine residue ( $\text{cm}^3$ )   | $110 \pm 30$  | $105 \pm 20$  | $>0.05$  |
| Mean urine flow rate (ml/sec)         | $8 \pm 1$     | $8.1 \pm 2$   | $>0.05$  |

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

**Table 2** Electromagnetic group (*N* = 10)

|  | Before    | After     | <i>P</i> |
|--|-----------|-----------|----------|
| 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 <sup>3</sup> ) | 33 ± 5    | 30 ± 2    | <0.04    |
| U/S urine residue (cm <sup>3</sup> )   | 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

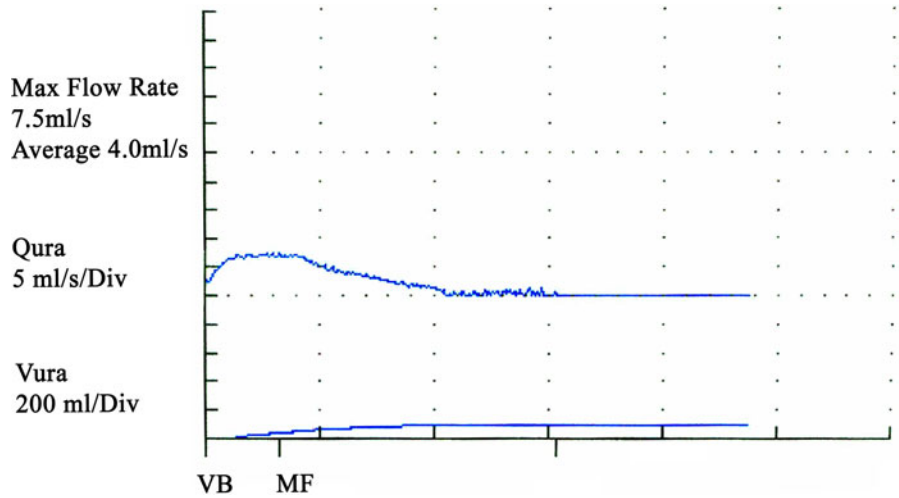
and U/S of prostate, and they all maintained the scores achieved after EMFs treatment. In contrast, all patients treated with α-blockers were submitted to prostatectomy within 30 days after a four-week

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.

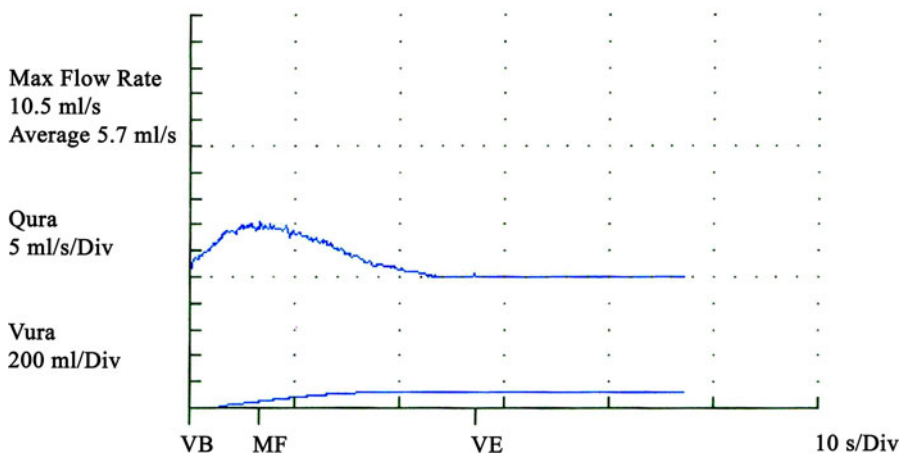
**Discussion**

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

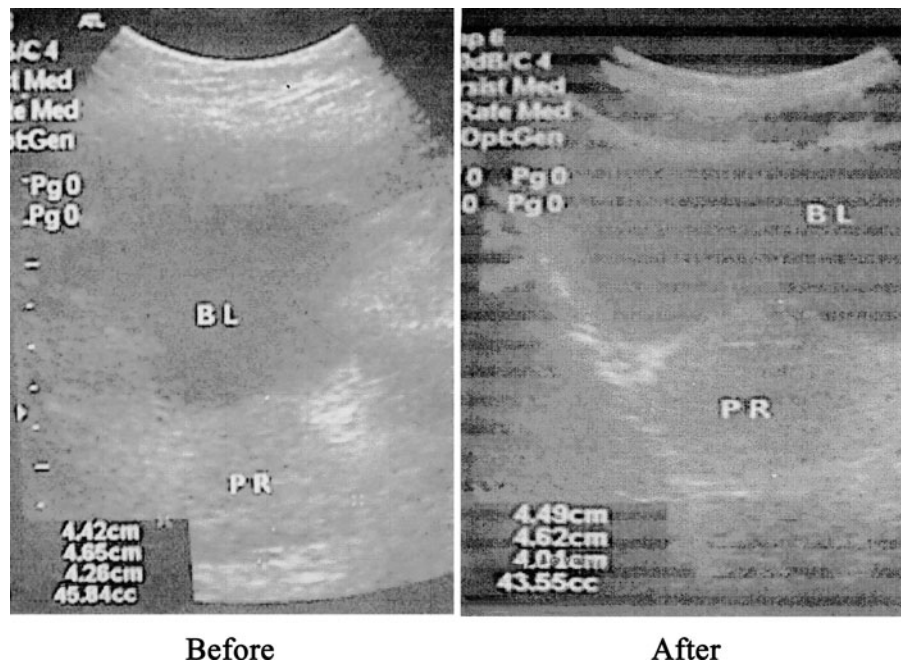
**Fig. 1** U/S (ultrasound) of prostate in a patient belonging to electromagnetic group (EG) before and after the EMFs treatment



**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  $\alpha$ -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  $\alpha$ -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  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , 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].  $\text{Ca}^{2+}$  intracellular signaling may induce alterations in the expression of various genes as well as apoptosis of abnormal cells [21]. EMFs may increase intracellular  $\text{Ca}^{2+}$  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- $\gamma$ , 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.

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## References

1. Foster KR, Repacholi MH (2004) Biological effects of radiofrequency fields; does modulation matter? *Rad Res* 162:219–225
2. Tofani S, Cintonino M, Barone D et al (2002) Increased mouse survival, tumor growth inhibition and decreased immunoreactive P53, after exposure to magnetic fields. *Bioelectromagnetics* 23:230–238
3. Stronati L, Testa A, Villani P et al (2004) Absence of genotoxicity in human blood cells exposed to 50 Hz magnetic fields as assessed by comet assay, chromosome aberration, micronucleus, and sister chromatid exchange analyses. *Bioelectromagnetics* 25:41–48
4. Karkabounas S, Havelas K, Kostoula OK et al (2006) Effects of low intensity static electromagnetic fields on leiomyosarcoma and smooth muscle cell lines. *Hell J Nucl Med* 9:167–172
5. Charles L, Loomis D, Shy C et al (2003) Electromagnetic fields, polychlorinated biphenyls, and prostate cancer mortality in electric utility workers. *Am J Epidemiol* 157: 683–691
6. Sauer H, Hescheler J, Reis D et al (1977) DC electrical field-induced c-fos expression and growth stimulation in multicellular prostate cancer spheroids. *Br J Cancer* 75: 1481–1487
7. Islamov BI, Balabonova RN, Futnikov VA et al (2002) Effect of bioresonance therapy on antioxidant system in lymphocytes in patients with rheumatoid arthritis. *Bull Exp Biol Med* 134:248–250
8. Athanasiou A, Karkabounas S, Batistatou A et al (2007) The effect of pulsed electromagnetic fields on secondary skin wound healing. An experimental study. *Bioelectromagnetics* 28:362–368
9. Weintraub MI, Wolfe GI, Barohn RA et al (2003) Static magnetic field therapy for symptomatic diabetic neuropathy: A randomized double-blind, placebo-controlled trial. *Arch Phys Med Rehabil* 84:736–746
10. Ahmed M, Bell T, Lawrenxe WT et al (1997) Transurethral microwave thermotherapy (Prostatron version 2.5) compared with transurethral of the prostate for the treatment of benign prostatic hyperplasia a randomized, controlled, parallel study. *Br J Urol* 79:181–185
11. Anson KM, Seenivasagam K, Watson GM (1994) Visual laser ablation of the prostate. *Urology* 43:276
12. Bagley D, Erhard M (1995) Use of the holmium laser in the upper urinary tract. *Tech Urol* 1:25–30
13. Giannakopoulos X et al. (1996) Transurethral needle ablation (TUNA) of the prostate: preliminary results using the new generation TUNA III catheter on patients with symptomatic BPH controlled by a series of 50 patients using the TUNA II device. In: Abstracts of the XIIth Congress European Association of Urology, Paris, France, 1–4 September 1996
14. Gilling PJ, Cass CB, Cresswell MD et al (1996) Holmium laser resection of the prostate: preliminary results of a new method for the treatment of benign prostatic hyperplasia. *Urology* 47:48–51
15. Madersbacher S, Pycha A, Klingler CH et al (1999) The International Prostate Symptom score in both sexes: a urodynamics-based comparison. *Neurourol Urodyn* 18: 173–182
16. Anninos P, Papadopoulos I, Kotini A et al (2003) Differential diagnosis of prostate lesions with the use of bio-magnetic measurements and non-linear analysis. *Urol Res* 31:32–36

17. Bellofonte C, Vedruccio C, Tubolini P et al (2005) Non-invasive detection of prostate cancer by electromagnetic interaction. *Eur Urol* 47:29–37
18. Suss S (1997) Bioresonance therapy in the treatment of allergies. Every person has its own vibration pattern. *Fortschr Med* 115:16–18
19. Panagopoulos JD, Messini N, Karabarbounis A et al (2000) A mechanism for action of oscillating electric fields on cells. *Biochem Biophys Res* 272:634–640
20. Chiabrera B, Bianco B, Moggia E et al (1994) Interaction mechanism between electromagnetic fields and ion absorption: endogenous forces and collision frequency. *Bioelectrochem Bioenergetics* 35:33–37
21. Carafoli E (2004) The ambivalent nature of calcium signal. *J Endocrinol Invest* 27:134–136
22. Pessina GP, Aldimucci C, Palmi M et al (2001) Pulsed electromagnetic fields affect the intracellular calcium concentrations in human astrocytoma cells. *Bioelectromagnetics* 22:503–510
23. Ikehara T, Park KH, Yamagushi H et al (2002) Effects of time varying strong magnetic field on release of cytosolic free  $\text{Ca}^{2+}$  from intracellular stores in cultural bovine adrenal chromaffin cells. *Bioelectromagnetics* 23:505–515
24. Abeele FV, Skryma R, Shuba Y et al (2002) Bcl-2-dependent modulation of  $\text{Ca}^{2+}$  homeostasis and store operated channels in prostate cancer cells. *Cancer Cell* 1:169–179
25. Kramer G, Mittereyer D, Marbeger M (2007) Is benign prostate hyperplasia (BPH) an immune inflammatory disease? *Eur Urol* 51:1202–1216
26. Johnson MT, Waite LR, Nindl G (2004) Non-invasive treatment of inflammation using electromagnetic fields: current and emerging therapeutic potential. *Biomed Sci Instr* 40:469–474
27. Jorgensen WA, Frome BM, Wallach C (1994) Electrochemical therapy of pelvic pain: Effects of pulsed electromagnetic fields (PEMF) on tissue trauma. *Eur J Surg Suppl* 574:83–86
28. Mihajlovic-Madzarevic V, Pappas P (2005) Treatment of refractory seizures due to a benign mass present in the corpus callosum with an ion magnetic inductor: case report. *Brain Tumor Pathol* 22:93–95