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Therapeutic Effects of Low Frequency Pulsed Electromagnetic Fields on Rat Liver Cancer.

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Abstract - *The attempts made to treat invasive liver cancer have failed so far at an alarming rate. One effective strategy used recently is low frequency pulsed magnetic field therapy. Coil A of intensity 13-42 gauss; 2-3 Hz and Coil B of 0.6 Tesla <1 Hz were evaluated on diethylnitrosamine-induced rat liver cancer. Furthermore, an exposure system was designed to provide a safe, selective and a noninvasive therapeutic device designed according to the international safety standards of therapeutic devices. The histopathology and ultra-structure of liver tissues suggest a selective anticancer activity of these magnetic fields through incorporating three main strategies. These strategies consist of apoptosis, necrosis and the inflammatory infiltration of the malignant carcinoma. These results simulate the gene therapy and immunogenic therapy of liver cancer. Finally, it can be concluded that the exposure system coil A of 3 Hz and coil B 0.9 Hz will contribute to magnetic therapy.*

Keywords *- Diethylnitrosamine, Liver cancer, Low frequency pulsed magnetic field therapy.*

I. INTRODUCTION

Many experiments have been carried out to investigate the effect of magnetic fields on tumor cell growth. Two kinds of frequency range result in completely different biological effects. For example, Chang et al. (1985) reported that "pulsed magnetic field (0.8 T, 22 ms, 1 Hz) inhibited the growth of S-180 sarcoma in rats, and used the same magnetic field strength to treat patients with middle and late-stage disease [1]. Nine of 18 cases showed good improvement and nine were less well inhibited [2]. Zhang et al. (2002) reported that Extremely low frequency (ELF) pulsed-gradient magnetic field (with the maximum intensity of 0.6–2.0 T, gradient of 10–100T, pulse width of 20–200 ms and frequency of 0.16–1.34 Hz treatment of rats can inhibit murine malignant tumor growth through activation of oncolytic ability of host immune cells [3]. Tatarove et al. (2011) reported that direct exposure of mice to magnetic fields reduced tumor growth and progression. Mice exposed to magnetic fields for 360 min daily for as long as 4 weeks showed extensive areas of necrosis in their tumors [4]. The aim of this study was to investigate the therapeutic effects of Schumann device (coil A) and pulsed gradient magnetic field (Coil B) on chemically induced Hepatocellular carcinoma (HCC).

II. METHEDOLOGY

Two coils: Schumann device (Coil A) 13-42 gauss, 2-3 Hz and Pulsed gradient magnetic field source (Coil B) 0.6 Tesla, <1 Hz were designed as the electromagnetic exposure system. Diethylnitrosamine (DEN) was used to induce rat-HCC by multiple intraperetoneal doses [5]. HCC induction was confirmed histopathologicaly and biochemically. A total of 60 rats were divided into six groups: 3 normal control groups (two exposed groups to magnetic fields and one unexposed group), a two HCC exposed groups one for each coil as well as a one HCC unexposed group. Exposure period was for coil A; (30 min./day/ rat) and for coil B; (15 min./day/ rat), for 6 days/week for 4 successive weeks. Histopathological, Electron Microscope (EM) and blood sampling procedures (including: Osmotic Fragility, Alfa Feto protein and liver function enzymes) were studied carefully during and at the end of exposure period. Also Dielectric properties of liver tissues were studied.

III. RESULTS

Normal animals exposed to pulsed magnetic fields from both coil A and coil B showed no histopathological changes and had a nearly normal architecture. Also dielectric properties, OF livers and blood tests were fluctuated within the physiological norms for this species. Such results suggest the safety of the used

magnetic fields. The lack of adverse reactions in normal cells suggested that the safety of this treatment may be related to its ability to influence prefentially and selectively with the transformed cells.

Upon exposure of HCC groups to pulsed magnetic fields, we reported significant decrease in AFP level and other blood tests; also we reported slight improvement in dielectric properties of livers which suggests the anticancer activity of these magnetic fields. Such results confirmed by EM (see fig.1) and histological HCC regression (see fig.2) through activating apoptosis, necrosis and inflammatory infiltrate.

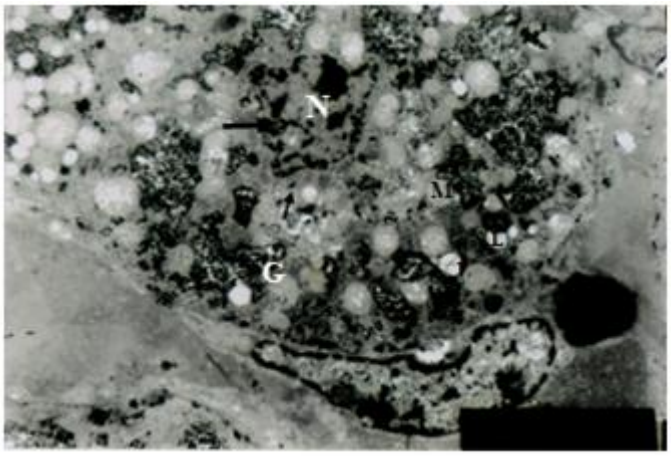

Fig.1: Liver cell of HCC + coil B group showing central pyknotic nucleus (N) with irregular contour, numerous outer blebs (arrow) showing prominent chromatin clumping and fragmentation with numerous nuclear pores. Cytoplasm is studied with numerous lipid vacuoles (L) and swollen mitochondria (M) among aggregates of glycogen granules (G). (X 4000).

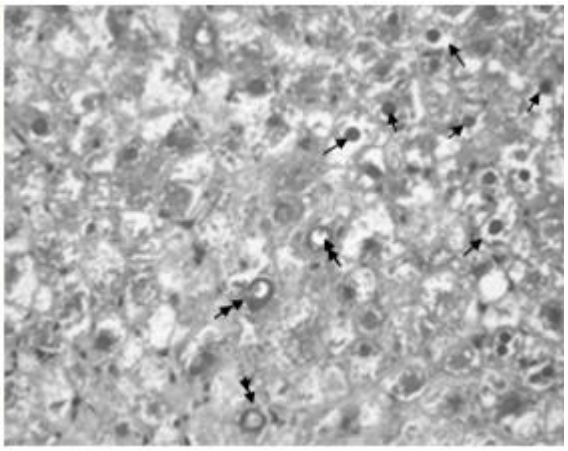

Fig.2: Well differentiated HCC treated by coil A showing high number apoptotic figures (arrows); some have ring forms (double arrow heads). (H&E X 400).

IV. CONCLUSION

The exposure system Schumann device; (coil A; 13-42 gauss, 2-3 Hz) and Pulsed gradient magnetic field (coil B; 0.6 Tesla, <1 Hz) provide a safety, selective, noninvasive, painless, drug free and low cost therapeutic devices. The histopathology and ultra-structure of liver tissues suggests a selective anticancer activity of magnetic fields from the exposure system through incorporating three main strategies: apoptosis, necrosis and inflammatory infiltration of the hepatocellular carcinoma. The obtained results on HCC regression simulate the gene therapy and immunogenic therapy of liver cancer. Nearly the results of two coils (coil A and coil B) were similar despite the difference in specifications, indicating that low frequency pulsed magnetic field itself did not affect the cancer cells directly but increased the host immune system against cancer, so we suggest using coil A for superficial tissues and coil B for deeper tissues.

V. ACKNOWLEDGEMENTS

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