

Some Aspects of the Labor Risk in Physiotherapy Due to Microwaves

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Abstract: - In physical rehabilitation, physiotherapists can use electrotherapy and radiofrequency diathermy. Microwave diathermy is used in medical therapy to produce local heating in tissue by means of converting electromagnetic energy into thermal energy. The interaction of the microwave radiation with human beings depends on many parameters. Sometimes, this microwave exposure causes some diseases or disorders both in patients and in the operators of the microwave device, that is to say, the physiotherapist. In order to avoid these disorders, some measures are proposed.

Key-Words: - Microwave, radiofrequency, labor risk, physiotherapy, diathermy, SAR, exposure

1 Introduction

Microwave diathermy is used in medical therapy to produce local heating in tissue by means of converting electromagnetic energy into thermal energy. This type of therapy has been used since thirties [1].

The interaction of the microwaves and radiofrequencies radiation with human beings, or at least great part of them, depends on many parameters [2]. The biological responses of the human beings are due to the electromagnetic fields. The electric properties of the human beings and their geometry determine the quantity of radiation that reflects, transmits and absorbs for a certain kind of exposure field. This exposure field is characterized by the frequency, intensity,

polarization, the proximity of the radiator device, etc.

The interaction of the radiofrequencies fields with living systems may be appreciated in a macroscopic and microscopic (molecular, cellular) level [4]. On the molecular level, two basic mechanisms govern the interactions: the space charge polarization at lower radiofrequencies and the field-induced rotation of polar molecules at higher frequencies (such as microwave frequencies). The polarization of the space charge is due to traveling charges, for example, the ions that are affected by the applied field and that are moving all around the space (a room, a laboratory, a ward, etc.). Polar molecules, that is to say, molecules that have uneven spatial distribution of charges (like water and proteins) suffer a torque, a rotation, when placed in an electric field.

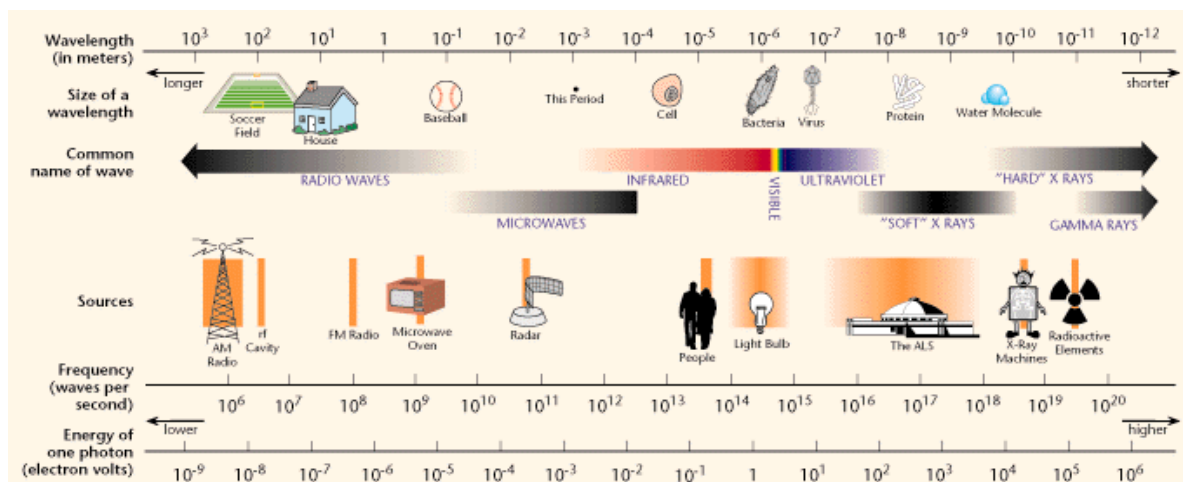


Fig. 1. Electromagnetic spectrum

Moderate exposure fields only affect to a small number of molecules or charges. Normally, they align with the direction of the applied field. The movements are hindered by the thermal motion of molecules and charges, and the kinetic energy transforms into thermal energy. So, the electromagnetic energy is converted into kinetic one (movement of the molecules) and afterwards consequently into thermal energy.

The mechanism that appears at a very extremely low frequencies (ELF), that is, under 100 Hz, and with amplitudes of radiofrequencies modulated to ELF frequencies is quite different for some specific interactions. In this case, there is a great dependence on the frequency and the amplitude of the applied field.

2 Effects of the Microwave Exposure

The electromagnetic fields which produce biological effects are measured by the specific absorption rate (SAR) which expresses the rate of energy absorption and is proportional to the square of the internal electric field intensity. The proportionality constant depends on the electrical properties of the tissue. The average SAR for the whole body, far away from the field radiator, depends on the field frequency, intensity, direction of the applied field, size and shape of the subject, and the presence of other objects around (particularly, metal objects). However, there are no simple methods of directly measuring the average SAR in persons. When exposure occurs in the direction of the wave and for a given size and shape of a living system, it has been shown [5] that there is a frequency at which the absorbed amount is maximum. This frequency is called the resonant frequency.

The maximum absorption not only occurs at this resonant frequency but in a range of frequencies around it the distribution of the absorbed power in the body is highly non-uniform.

Besides, there are spots inside the body where the absorption increases, is higher, and they are called hot spots. For human beings, the maximum energy absorption takes place between 30 and 100 MHz, depending on the body size and the environment. For an average person isolated from ground, the frequency of the maximum absorption is about 80 MHz. For small experimental animals, this frequency is much higher (900 MHz for a rat and 2000 MHz for a mouse).

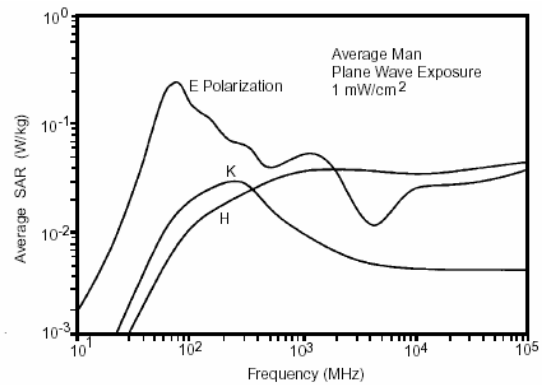


Fig. 2. Average specific absorption rate for an average man exposed to 1mW/cm² plane wave. E polarization denotes the electric field parallel to the body, H denotes the magnetic field parallel to the body and K denotes the wave moving from head to toes or toes to head

Biological effects of radiofrequencies have been investigated in several types of animals and the greater part (but not all) of the effects are thermal. However, this does not indicate that there is a mere heating, but the effects of the radiofrequency induced heating are: several depth of penetration, the existence of internal hot spots, and the rapidity of heating. Moreover, the induction of non-uniformities in the temperature of various parts of the brain may cause some alterations.

The thermogenic effects of the radiofrequencies where explained in 1979 [10]:

- Biological effects appear due to the thermoregulatory response when an animal is exposed at a rate equal to its basal metabolic rate (BMR)
- Numerous behavioral, endocrine, cardiac and respiratory effects for SARs below the BMR are manifestations of psychological responses to mild thermal stress
- The thermal stress that results from and exposure of about twice the BMR, maintained over long periods of time, leads to important psychological effects

The effects on the eyes and gonads have been investigated thoroughly. These organs are very susceptible to heat [5]. The radiation of microwaves at frequencies above 800 MHz may produce injury to the eye. The type of the injury depends on the frequency, for example millimeter waves can produce keratitis. Furthermore, cataracts are developed after a long exposure to power densities above 100 mW/cm².

Former studies on genetic effects due to microwaves in bacteria, flies, various plants and animal cells, and tissue cultures do not probe that

radiofrequencies can lead to any mutation in living systems other than through induction of heat. Regarding this subject, it is known that the rate of induction of mutation increases with increasing temperature.

Studies of effects of radiofrequencies exposure on teratogenesis make us know that there is a absorbed dose-response relation. Only intense fields that cause a great heating are associated with a induction of teratogenesis.

When the exposure to electromagnetic fields is at relatively low levels (below 10mW/cm^2), it does not induce cardiovascular disturbances. Some cardiovascular responses may result from the effects of the applied field on the nervous system.

The radiofrequency exposure effects on the central nervous system (and also its relation with the behavior of the exposed subjects) are one of the most controversial points. In the USSR and some Eastern European countries it was asserted that a exposure to low level radiation (called athermal) caused neurastenic disorders [5] [6]. On the other hand, it is widely known that the radiofrequency exposure may disrupt animal behavior, so the threshold value of the SAR for the effect was been established.

In microwave diathermy therapy strong and irregular leakage fluxes may result outside the treatment area [3] [12]. High intensity fields are also produced near the cables of the device. And although there is no simple formula to predict the intensities of far leakage fields, it is known that the bigger is the applied power stronger are the leakage fluxes.

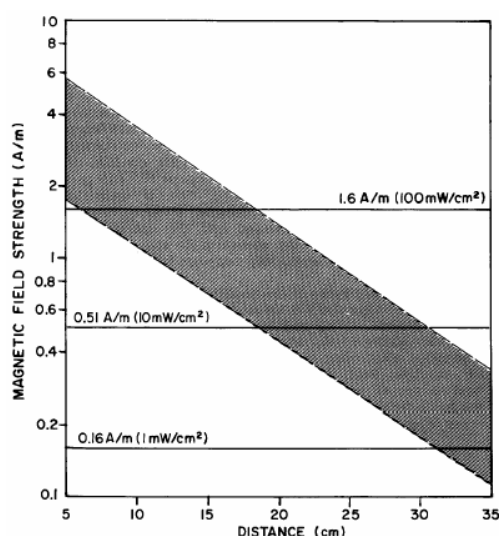


Fig. 3. Range of the magnetic field intensities around cables of the microwave device for various types of electrodes and typical power settings.

In figures 3 and 4, the typical ranges of the magnetic and electric field intensities around the cables of the diathermy device are shown.

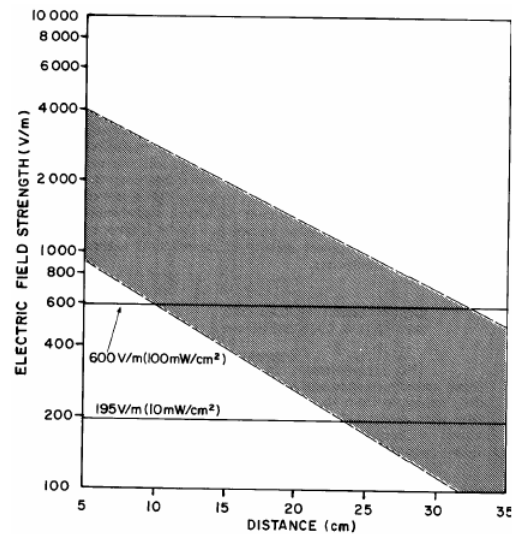


Fig. 4. Range of the electric field intensities around cables of the microwave device for various types of electrodes and typical power settings.

The intensity of the fields around the cables depends on the type and design of electrode, the applied power, the treated part of the patient, and the placement of the electrode over the area being treated. The intensity decreases with the distance to the electrodes and is always highest in the plane of the applicator, that is, in front the electrodes. However, disturbances to the leakage field can be introduced by metal objects. The intensity of the fields usually drop to below an equivalent power density of 1mW/cm^2 at a distance of less than 1 m, but in the configuration of the next figure fields with an equivalent power density of 10mW/cm^2 at a distance of 1 m have been observed.

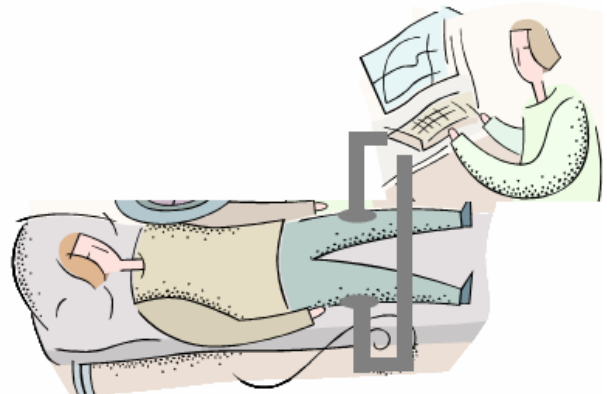


Fig. 5. Diathermy treatment configuration producing high intensity leakage fields

3 Measures to Reduce the Microwave Exposure

Both to minimize the exposure not only of the operators but also of the patients near the microwave devices and to avoid interferences among various treatments carried out in the same electrotherapy ward, some solutions should be taken into account:

a) **Metallic meshes – Faraday cage.** The Faraday cage consists of a shield room designed to prevent the passage of electromagnetic waves, either containing them in or excluding them from its interior space. Inside the walls there is a metallic mesh of different materials (copper, bronze) with different number and shape of thread per cm². All the gaps have to be screened to absorb any reflected radiofrequency. Furthermore, Faraday cage must have specific ground connection. Mathematically, we can consider an idealized hollow electrical conductor such as an empty sphere or box. If the outside of the cage is an idealized conductor, it will form an equipotential surface, that is to say, its surface will have the same electrical potential at every point. If there is no electrical charge inside the box, then by Gauss' law and the divergence theorem there should be no electrostatic field inside the equipotential surface, regardless of what the field is outside the box. Since the electrostatic field equations are linear, this means that even if there are charges in the box to generate a field, they will still not be affected by any fields outside the box.

Thanks to shielding system it is easy to avoid the radiofrequency exposure in a 100%. Some cages or mesh devices reduce the radiation of 50/120 dB.

Various companies (Enraf Nonius, Holland Shielding Systems B.V., etc.) provide these devices.

- b) Increase the distance between emitter (microwave device) and receiver (patient or operator) because the radiation intensity from the emitter is inversely proportional to the square of the distance. This may be a solution to reduce the exposure of the persons who neither operate nor are treated (such as other patients and other physiotherapists who are in the same ward). Anyway, it is obvious that the microwave device has to be controlled by the operator, so even though distance may be increased, the use of remote controls can make easier and safer the radiofrequency operation.
- c) **Drilling panels.** This solution consists of a room where the walls are metallic panels. These panels have been drilled, that is to say, they are full of holes. The attenuation depends on the width of the panels and on size of the holes, among other variables.
- d) **Locking rooms.** It is the previous solution (drilling panels) but no holes are made in it.

4 Conclusion

The interaction of the radiofrequencies fields with living systems, particularly microwave exposure in physiotherapy treatment, is presented in this paper. The biological responses of the human beings are due to the electromagnetic fields. Although there are studies that say there is not a direct relation among microwave exposure and the likely diseases or disorders in living systems, there are other investigations that conclude the opposite: some parts of the animals or persons (eyes, gonads, brain, etc.) are affected by microwave exposure.

Some measures are proposed to avoid the disorders. Some of them are very easy and simple, such as increasing the distance among patients and operators with microwave device, and others are more expensive but more efficient, such as Faraday cage.

The inclusion of these measures, or at least one of them, is not only responsibility of the operator but of the institution where the treatment is carried out.

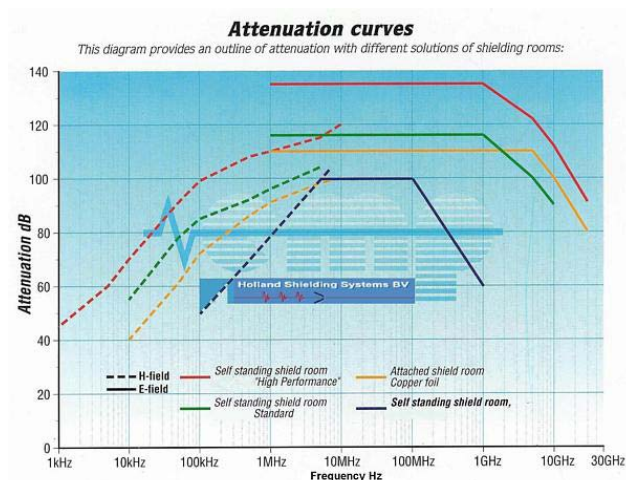


Fig. 6. Attenuation curves of various type of shielding rooms manufactured by Holland Shielding Systems B.V.

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