

Application of microwave radiation in cancer

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ABSTRACT

Radio Frequency Ablation (RFA) and Microwave Ablation (MWA) are therapies that use image guidance to insert a needle into a liver tumor through the skin. High-frequency electrical currents are sent through an electrode in the needle during RFA, resulting in a tiny zone of heat. Microwaves are generated from the needle in MWA to create a small zone of heat. The heat kills the cancer cells in the liver. RFA and MWA are excellent therapeutic choices for individuals who are unable to undergo surgery or have tumors that are less than one and a half inches in diameter. Small liver tumors can be entirely removed with a success rate of more than 85%. The amount of heat produced is determined by the intensity of the radiation, the electrical characteristics of the exposed tissue, and the body's thermoregulatory

mechanism. There is no evidence that microwaves cause cancer. Microwave ovens employ microwave radiation to heat food, however this does not imply that the food becomes radioactive as a result. Microwaves heat food by causing water molecules to vibrate, which causes the food to heat up. There is no evidence that microwaves cause cancer.

Key Words: *Electromagnetic; Radiation; Cancer; Tumor; Microwave*

INTRODUCTION

Microwaves are electromagnetic waves that range in frequency from 300MHz to 300GHz. Microwaves are widely employed in in households, industry, communications, and medical and military buildings, and they make significant contributions to human society's progress. However, as it has gained popularity, more attention has been drawn to its impact on humans [1]. Electromagnetic radiation can be absorbed by organisms, causing a variety of physiological and functional changes. Many intricate electrical functions, including learning and memory, take place in the central nervous system, making it vulnerable to electromagnetic radiation. Furthermore, the widespread use of mobile phones has made them the primary source of radiation exposure to the brain. Radio Frequency Microwaves (RFM) have a wide range of effects on the biological system and have a significant impact in medical applications, such as heating, changing chemical processes, and producing electrical current in tissues and cells. The ability to compute the deposition of electromagnetic radiation in a range of diagnostic procedures and therapies requires understanding of temperature-dependent electrical characteristics of biological tissues. Every molecule in a biological system is constantly generating an electromagnetic field as a result of thermal agitation of charged particles, which is directly proportional to its frequency, thus the higher the frequency, the greater the energy, as demonstrated by the photon energy formula [2].

Human tissues can be addressed electrically by modelling them as a two-port network with its own scattering matrix or S-parameters. These S-parameters will vary depending on the type of tissue (normal or malignant). By measuring the varying amounts of MW radiation absorbed or reflected by the tumor model, the scattering matrix analysis may determine the type of malignant tissues such as melanoma, carcinoma, sarcoma, and so on. We can classify and characterize the various radar returns using this manner until enough data is collected, evaluated, and used as a lookup table and data base. The present improvement in research technology, particularly communications, has prompted serious worries about the potential effects of excessive RF/MW exposure [3]. The effects of RF interaction with the body can be classified as thermal or non-thermal, and the mechanism of RF interaction with the body is increased tissue or body temperature, which is responsible for cellular and intracellular alterations. The amount of heat produced is determined by the intensity of the radiation, the electrical characteristics of the exposed tissue, and the body's thermoregulatory mechanism. The exposure level established in the United States, adheres to a level of 10 mW/cm² averaged over 0.1 h [4]. The minimum energy required for these processes is reported to be greater than 26 meV, the average energy of thermal noise measured at body temperature. These effects could only be seen if particular biological structures vibrated at the same frequencies as the applied Electromagnetic Field (EM).

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Microtubule reassembly, for example, was linked to the peak of cellular EM field emission during replication, implying a critical function in their formation. Surprisingly, microtubules can vibrate at frequencies ranging from kHz to GHz.

RF/MW radiation appears to cause electric oscillations that disrupt cell membrane proteins, thereby initiating enzyme cascades that may convey cell surface signals to the intracellular system. Foster et al. conducted a study on RF-induced increases in skin temperature in the frequency range from 3 GHz to millimeter frequency range in 2016. (30GHz-300GHz). They created a model based on Pennes Bio Heat Equation (BHTE), and the parameter analysis revealed that for small irradiated areas (less than about 0.5cm-1cm in radius), temperature increase at the skin surface is primarily limited by heat conduction into deeper tissue layers, whereas for larger irradiated areas, steady-state temperature increase is limited by convective cooling by blood perfusion. The study supported the application as well as its limits. RF/MW radiation causes electric oscillations that disrupt cell membrane proteins, initiating enzyme cascades that may convey cell surface signals to the intracellular system [5].

NORMAL AND MALIGNANT HUMAN TISSUE DIELECTRIC PROPERTIES

Every cell and tissue in the human body has a unique electric environment and responds differently when exposed to MWs. Dielectric characteristics at MW frequencies are determined by water content and are consequently less impacted by tissue removal than at RF frequencies. Temperatures beyond 50°C-60°C are likely to cause irreversible changes in electrical characteristics as a result of dehydration, perfusion shutdown, and other cellular and molecular alterations, and can be accountable for cancerous tissue or cells. MW Imaging Ultra-Wide Band (UWB) Antenna Sensor Base: observing an object's interior structure using electromagnetic waves at MW frequencies ranging from 300 MHz to 30 GHz [6]. MW imaging techniques have been extensively researched as a viable diagnostic tool for early-stage cancer diagnosis that is both quick and cost-effective. Ultra-Wide Band (UWB) antenna imaging technology has been around for a decade and is mostly used to identify breast cancer. The antenna serves as both a sending and receiving sensor. Breast tissues are exposed to MW signals from a transmitting sensor, and backscattered signals from the breast tissues are captured by receiving sensors. The variations in the backscattered signal are evaluated and used to identify tumor cells within the breast, which have greater dielectric constants than normal cells. MW tomography and Ultra-Wide Band (UWB) radar imaging are also becoming more popular for breast cancer detection, and UWB radar imaging is useful for histology procedures.

MW-induced Thermoacoustic Imaging (TAI)

TAI operates on the same basic principle as PAI, with the exception that short electromagnetic pulses between 0.3GHz and 3GHz are utilized as the excitation source, and pictures are proportional to the absorbed MW energy. TAI has been proposed as a novel approach for diagnostic breast imaging because tumors with higher water content absorb MWs differently than surrounding tissue (e.g., adipose), and a pilot study at 434 MHz revealed 3D in vivo images of the human breast with excellent sensitivity for detecting tumors [7]. However, in these early studies, limitations in MW and ultrasound hardware hampered high resolution characterization and precise classification of worrisome tumors. The two percutaneous thermal ablative procedures for the treatment of unresectable malignancies are Radio Frequency Ablation (RFA) and Micro-Wave Ablation (MWA), and the crucial parameters for MW ablation are relative permittivity and effective conductivity.

When compared to surgical resection, percutaneous image-guided ablation provides a minimally invasive therapy source that is excellent for no operative candidates; however, the rate of blood perfusion in each tissue is critical for both RF and MW ablation. Low-frequency RF MWs have also been shown to destroy cancer cells, making them cytotoxic, and may be a promising approach for the treatment of cancers of diverse sources. Furthermore, percutaneous radio-frequency ablation is widely acknowledged as the first-line treatment for early-stage Hepatocellular Carcinoma (HHC), and numerous randomized controlled trials have demonstrated significant efficacy. Furthermore, percutaneous radio-frequency ablation is widely acknowledged as the first-line treatment for early-stage Hepatocellular Carcinoma (HHC), and many randomized controlled trials have revealed significant differences between these local ablation procedures. MW technology is a revolutionary thermal ablation treatment for many types of malignancies that provides all of the benefits of radio frequency as well as significant advantages. Hormone treatment, surgical resection, and radiation therapy with minimum toxicity MWA may provide greater local control in bigger and perivascular tumor.

MECHANISM OF MW-INDUCED HYPERTHERMIA

The mechanism of MW-induced cell death is yet unknown and being researched. However, some new research indicates that the anti-cancer impact of MWs is attributable to cellular alterations such as enhanced cellular permeability, cytoskeleton disassembly, larger tumor pores, protein denaturation, DNA fragmentation, or strand breaking, all of which contribute to death.

SOME COMMON USES OF MICROWAVE

Microwave ovens heat foods by emitting extremely high quantities of RF radiation at a certain frequency (in the microwave spectrum). When food absorbs microwaves, the water molecules in the meal vibrate, producing heat. Microwaves do not employ x-rays or gamma rays, nor do they render food radioactive.

The Transportation Security Administration (TSA) uses full body scanners to screen passengers at numerous airports in the United States. The TSA's current scanners use millimeter wave imaging. These scanners emit a modest amount of millimeter wave radiation (a form of radiofrequency radiation) at the person inside the scanner. Cell phones and cell phone towers (base stations) broadcast and receive signals via RF radiation. Some have expressed concern that these signals may increase the risk of cancer, and study in this area is ongoing.

Using the extensive basic information gained from repeated tests, we used our microwave tissue coagulator in endoscopic surgery on 59 patients with benign and malignant tumors during a two-year period beginning in July 1981. Hemostasis was established in 96.5% of all cases with gastric bleeding lesions. Stenosis was relieved in 86% of cases with esophageal or rectal stenosis. Furthermore, the procedure was utilized successfully for hemostasis and tumor reduction in situations with inoperable early cancer. Our gadget is unusual in that the electrode is driven into tissue, ensuring a successful outcome. At this point, it must be separated from an electro coagulator or a laser coagulator, both of which are associated with a risk of infection. At this stage, it must be separated from an electro coagulator or a laser coagulator, both of which pose a danger of damaging intact tissue. The range of coagulation can be adjusted by varying the length of the nonpolar antenna and electric output, as well as by using an appropriate thickness coaxial cable. Finally, our microwave tissue coagulator is simple and safe to utilize in clinical endoscopic surgery. The response of the rat rhabdomyosarcoma R1H to single doses of X-rays applied alone or in combination with hyperthermia was studied.

Tumors of 2.3cm³ growing in the animals' flanks were treated locally with 15 Gy and 30 Gy of 200-kV X-rays and/or microwaves of 2450 MHz using a non-contact applicator. The temperature of the tumor's as well as the animals' bodies was measured using thermocouples. Heating the tumors at 43°C for different time intervals resulted in a regrowth delay that increased linearly with treatment time. Hyperthermia was administered 20 min following irradiation in the combined treatments. When compared to irradiation alone, the rhabdomyosarcoma R1H showed improved volume shrinkage and tumors development delay after combination treatment. Post irradiation treatments at 43°C for 30 min and 60 min after a single dose of 15 Gy result in TER values of 1.3 and 1.8, respectively. The TER values observed after combining a 30 Gy dosage with hyperthermia at 43°C (30 minutes or 60 minutes) ranged from 1.5 to 1.7.

The anti-tumor efficacy against subcutaneous Lewis lung cancer in syngeneic mice was investigated after local microwave coagulation and subsequent intra-tumoral injection of micro particles encapsulating interleukin-2 and granulocyte-macrophage colony-stimulating factor. This treatment induced powerful systemic anti-tumor immunity, which protected treated mice from re-challenge with the same tumors cells and caused distal tumor's in a bilateral tumor model to be rejected. The cytotoxicity experiment revealed that both T- and natural killer cells functioned as effector cells in anti-tumor immunity.

These findings illustrate the clinical viability of microwave-pre-treated in situ cancer vaccination.

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