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Hazardous Effect of use of Microwave on Human Health

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ABSTRACT: The Food and Drug Administration (FDA) has regulated the manufacture of microwave ovens since 1971. Microwave oven manufacturers are required to certify their products and meet safety performance standards created and enforced by the FDA to protect the public health. Based on current knowledge about microwave radiation, the Agency believes that ovens that meet the FDA standard and are used according to the manufacturer's instructions are safe for use.

Microwave ovens are a convenient means to heat food and are generally safe when used correctly. Microwave ovens heat food using microwaves, a form of electromagnetic radiation similar to radio waves. Microwaves have three characteristics that allow them to be used in cooking: they are reflected by metal; they pass through glass, paper, plastic, and similar materials; and they are absorbed by foods.

A device called a magnetron inside the oven produces microwaves. The microwaves reflect off the metal interior of the oven and cause the water molecules in food to vibrate. This vibration results in friction between molecules, which produces heat that cooks the food.

KEYWORDS: FDA, microwave, agency, ovens, foods, magnetron, vibration, heat, hazards, impact

I.INTRODUCTION

Microwave ovens produce electromagnetic radiation.

You may find this concerning due to radiation's negative connotations. However, this is not the type of radiation associated with atomic bombs and nuclear disasters.[1,2]

Microwave ovens produce non-ionizing radiation, which is like the radiation from your cell phone — though much stronger.

Keep in mind that light is also electromagnetic radiation, so clearly not all radiation is bad.

Microwave ovens have metal shields and metal screens over the window that prevent the radiation from leaving the oven, so there shouldn't be any risk of harm.

Just to be on the safe side, don't press your face against the window and keep your head at least 1 foot (30 cm) away from the oven. Radiation decreases rapidly with distance.[3,4]

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Also, make sure that your microwave oven is in good condition. If it's old or broken — or if the door doesn't close properly — consider getting a new one.

Many plastics contain hormone-disrupting compounds that can cause harm.

A notable example is bisphenol-A (BPA), which has been linked to conditions like cancer, thyroid disorders, and obesity (7Trusted Source, 8Trusted Source).

When heated, these containers may leach compounds into your food.

For this reason, do not microwave your food in a plastic container unless it is labeled microwave safe.

This precaution is not specific to microwaves. Heating your food inside a plastic container is a bad idea — no matter which cooking method you use.[5,6]

Microwaves do leak radiation. Whilst radiation is a brilliant way to heat food, it's not great for humans. But don't panic just yet...there are strict limits on the amount that can leak from a microwave oven throughout its lifetime. You may not already be aware that other everyday items like your laptop and computers leak electromagnetic radiation, too and don't harm us. Like the microwave the levels of leaked radiation is far below the amount known to harm people.

If you're still not satisfied, it's important to note that the level of exposure dramatically reduces as you move away from a microwave oven. If you want to be extra cautious, you can simply stand away from it whilst it's on. In the worst case scenario, microwave radiation at these power levels would result in a mild warming effect, if anything. Unlike plastics and ceramics, metals reflect microwaves (which means they can't pass through). So if you put your microwave meal in a metal dish, it won't allow it to heat up correctly. Thinner pieces of metals, for example foils, can act as an antenna, which can create sparks. [7,8]This is extremely dangerous and could cause your microwave to set on fire. Boiling a cup of water in a microwave could cause it to explode. Water could be over-heated (perhaps even past boiling point), as it will just keep on heating up for a long as you've set it for. So when it is disturbed or moved, it's likely that the heat will release by erupting violently.

To avoid the dangers of microwaves when boiling water, heat a minimum amount of water and ensure you are regularly monitoring it. Or alternatively use a kettle, which is designed to heat water to boiling point. Microwave ovens have been becoming increasingly popular since the 1960's, due to their convenience, high energy efficiency, rapid processing time and ease of use. Researchers have since been investigating how microwaving foods may influence their nutrient content, in a good way OR a bad way.[9,10] In a study published in The Journal of Agricultural and Food Chemistry, it was found that broccoli retained all of its minerals when microwaved but lost vitamin C, which leached into the added water. Does this mean that we should avoid microwaving our vegetables? Not necessarily. Firstly, vitamin C is quite volatile in heat, so cooking in general causes its loss. Luckily, C is plentiful in raw fruits and vegetables, so you can compensate there. Now, here's the most interesting part: microwave cooking has been shown to produce the lowest antioxidant losses in 20 vegetables when compared to pressure-cooking, boiling or frying. That's really good news. What about omega 3 in fish? A study published in Food and Bioproducts Processing investigated the effects of different cooking methods on the nutrient content of seabass. Losses of omega 3 fats were higher in the microwaved seabass than in the fried seabass. However, the researchers agreed that the fried seabass added unwanted fats into the mix and wasn't as healthy as microwave cooking! When it comes to choosing

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a cooking method, it really comes down to you (or your client), your personal goals, which nutrients you want to get more of, and which ones you're trying to avoid! [11,12]

II.DISCUSSION

As I'm sure you've heard, concerns have also been raised about the use of plastic containers when microwaving food. When food is wrapped in plastic or placed in a plastic container and microwaved, chemicals from the plastic can leak into the food. This seems to be causing a lot of worry for people but, according to the Harvard Medical School, this is closely regulated: tests are conducted to ensure that unsafe amounts do not leach into foods and only containers that pass this test can state that they are approved for use in microwave ovens. On the other hand, the organisation Breast Cancer UK urges the authorities to ban BPA, a type of plastic not only used in microwave ovenware but also in most packaged products! So, if you're concerned about these risks, switch to the safest alternatives, such as glass and porcelain containers for microwave cooking. Some say that the energy given off by microwaves is enough to damage one's genetics (DNA) and subsequently cause cancer[13,14]. But is there any good evidence to support this theory? Several studies have been carried out using laboratory animals and in-vitro systems (outside of a living organism) but few have studied living, human tissue so it is difficult to find causal associations. In 1997, Peter Valberg reviewed all of the epidemiological studies at the time, which looked at the incidence and distribution of cancer in relation to microwave radiation exposure and tried to determine whether microwaves increased the risk of cancer in humans. He found very little evidence to support a causal relationship between this exposure and disease and, whilst considering what else was known about the mechanism that microwaves use, as well as what had been observed in animal studies, he concluded that microwaves do not cause cancer. This makes sense because we know that the non-ionising radiation used in microwave ovens is not powerful enough to transfer radiation into food; it can only cause the water molecules to move. Very few scientific studies have taken place since Valger's review. Having said that, a study printed in *Molecular and Cellular Biology* found that microwave radiation exposure did not show any signs of increased cancer risk in Swiss albino mice. A huge relief, wouldn't you say? Today, Cancer Research UK tell us that it's perfectly safe to use microwaves. They also say that as long as you follow a microwave's instructions for use (such as standing away from it while cooking and keeping the door shut), it will not cause you any harm[15,16].

III.RESULTS

Microwaves are non-ionizing radiation, which means that microwave photons do not contain sufficient energy to ionize molecules or break chemical bonds, or cause DNA damage, as ionizing radiation such as x-rays or ultraviolet can.^[22] The word "radiation" refers to energy radiating from a source and not to radioactivity. The main effect of absorption of microwaves is to heat materials; the electromagnetic fields cause polar molecules to vibrate. It has not been shown conclusively that microwaves (or other non-ionizing electromagnetic radiation) have significant adverse biological effects at low levels. Some, but not all, studies suggest that long-term exposure may have a carcinogenic effect.^[23]

During World War II, it was observed that individuals in the radiation path of radar installations experienced clicks and buzzing sounds in response to microwave radiation. Research by NASA in the 1970s has shown this to be caused by thermal expansion in parts of the inner ear. In 1955 Dr. James Lovelock was able to reanimate rats chilled to 0 and 1 °C (32 and 34 °F) using microwave diathermy.^[24]

When injury from exposure to microwaves occurs, it usually results from dielectric heating induced in the body. The lens and cornea of the eye are especially vulnerable because they contain no blood vessels that can carry away heat.[17,18] Exposure to microwave radiation can produce cataracts by this mechanism, because the microwave heating denatures proteins in the crystalline lens of the eye^[25] (in the same way that heat turns egg whites white and opaque). Exposure to heavy doses of microwave radiation (as from an oven that has been tampered with to allow operation even with the door open) can produce heat damage in other tissues as well, up to and including serious burns that may not be immediately evident because of the tendency for microwaves to heat deeper tissues with higher moisture content.[19,20]

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Implications

Microwave burns are burn injuries caused by thermal effects of microwave radiation absorbed in a living organism.

In comparison with radiation burns caused by ionizing radiation, where the dominant mechanism of tissue damage is internal cell damage caused by free radicals, the type of burn caused by microwave radiation is by heat—health effects colloquially associated with the term "radiation", such as radiation poisoning, cannot be caused by exposure to microwaves or other forms of non-ionizing radiation.[21,22]

Microwave damage can manifest with a delay; pain or signs of skin damage can show some time after microwave exposure.^[1]

The depth of penetration depends on the frequency of the microwaves and the tissue type. The Active Denial System ("pain ray") is a less-lethal directed energy weapon that employs a microwave beam at 95 GHz; a two-second burst of the 95 GHz focused beam heats the skin to a temperature of 130 °F (54 °C) at a depth of 1/64th of an inch (0.4 mm) and is claimed to cause skin pain without lasting damage. Conversely, lower frequencies penetrate deeper; at 5.8 GHz (3.2 mm) the depth most of the energy is dissipated in the first millimeter of the skin; the 2.45 GHz frequency microwaves commonly used in microwave ovens can deliver energy deeper into the tissue; the generally accepted value is 17 mm for muscle tissue.^[2]

As lower frequencies penetrate deeper into the tissue, and as there are fewer nerve endings in deeper-located parts of the body, the effects of the radio frequency waves (and the damage caused) may not be immediately noticeable. The lower frequencies at high power densities present a significant risk.

The microwave absorption is directed by the dielectric constant of the tissue. At 2.5 GHz, this ranges from about 5 for adipose tissue to about 56 for the cardiac muscle. As the speed of electromagnetic waves is proportional to the reciprocal of the square root of the dielectric constant, the resulting wavelength in the tissue can drop to a fraction of the wavelength in air; e.g. at 10 GHz the wavelength can drop from 3 cm to about 3.4 mm.^[3]

The layers of the body can be approximated as a thin layer of epidermis, dermis, adipose tissue (subcutaneous fat), and muscle tissue. At dozens of gigahertz, the radiation is absorbed in the top fraction to top few millimeters of skin. Muscle tissue is a much more efficient absorber than fat, so at lower frequencies that can penetrate sufficiently deep, most energy gets deposited there. In a homogeneous medium, the energy/depth dependence is an exponential curve with the exponent depending on the frequency and tissue. For 2.5 GHz, the first millimeter of muscle tissue absorbs 11% of the heat energy, the first two millimeters together absorb 20%. For lower frequencies, the attenuation factors are much lower, the achievable heating depths are higher, and the temperature gradient within the tissue is lower.^{[2][4]}

The tissue damage depends primarily on the absorbed energy and the tissue sensitivity; it is a function of the microwave power density (which depends on the distance from the source and its power output), frequency, absorption rate in the given tissue, and the tissue sensitivity. Tissues with high water (resp. electrolyte) content show higher microwave absorption.[23,24]

The degree of the tissue damage depends on both the achieved temperature and the length of exposure. For short times, higher temperatures can be tolerated.

The damage can be spread over a large area, when the source is a relatively distant energy radiator, or a very small (though possibly deep) area, when the body comes to a direct contact with the source (e.g. a wire or a connector pin).^[5]

The epidermis has high electrical resistance for lower frequencies; at higher frequencies, the energy penetrates through by capacitive coupling. Damage to epidermis has low extent unless the epidermis is very moist. The characteristic depth for lower-frequency microwave injury is about 1 cm. The heating rate of adipose tissue is much slower than of muscle tissue. Frequencies in millimeter wave range are absorbed in the topmost layer of skin, rich in thermal sensors. At lower frequencies,

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between 1–10 GHz, most of the energy is however absorbed in deeper layers; the threshold for cellular injury there lies at 42 °C while the pain threshold is at 45 °C, so a subjective perception may not be a reliable indicator of a harmful level of exposure at those frequencies.^[6]

Exposure to frequencies common in domestic and industrial sources rarely leads to significant skin damage; in such cases, the damage tends to be limited to upper limbs. Significant injury with erythema, blisters, pain, nerve damage and tissue necrosis can occur even with exposures as short as 2–3 seconds.[25,26] Due to the deep penetration of these frequencies, the skin may be minimally affected and show no signs of damage, while muscles, nerves, and blood vessels may be significantly damaged. Sensory nerves are particularly sensitive to such damage; cases of persistent neuritis and compression neuropathy were reported after significant microwave exposures.^[7]

Microwave burns show some similarities with electrical burns, as the tissue damage is deep rather than superficial. Adipose tissue shows less degree of damage than muscles and other water-rich tissues. (In contrast, radiant heat, contact burns and chemical burns damage subcutaneous adipose tissue to higher extent than deeper muscle tissue.)[27,28] Full-thickness biopsy of the area between burned and unburned skin shows layers of more and less damaged tissue ("tissue sparing"), layers of undamaged fat between damaged muscles; a pattern that is not present in conventional thermal or chemical burns. Cells subjected to electrical burns show microscopic nuclear streaming on histology examination; this feature is not present with microwave burns.[29,30] Microwaves also deposit more energy to areas with low blood supply and to tissue interfaces.^{[1][8]}

Hot spots may be formed in the tissue, with a consequent higher absorption of microwave energy and even higher temperature achieved, with localized necrosis of the affected tissue following.^[9] Sometimes, the affected tissue can even be charred.^[10]

Muscle tissue destruction can lead to myoglobinuria, with renal failure following in severe cases; this is similar to burns from electric current. Urinalysis and serum CPK, BUN and creatine tests are used to check for this condition.^[11]

Cases of severe conjunctivitis were reported after technicians looked into powered waveguides.^[4]

Microwave-induced cataracts have been reported.^[12] Experiments on rabbits and dogs, mostly in the UHF range of frequencies, shown that the ocular effects are confined to eyelids and conjunctiva (as e.g. anterior segment keratitis or iritis).^[7] Cataracts were observed at several workers exposed to radiofrequency radiation, but in some of the cases the cause was unrelated to the RF exposure and in the other cases the evidence was incomplete or inconclusive.^[9] Some sources however mention incidence of microwave-related injuries of ocular lens and retina^[13] and the possibility of thermal effects to cause cataracts or focal tissue burns (incl. keratitis).^[14]

For the near field 2.45 GHz frequency, the minimum power density to cause cataracts in rabbits was found to be 150 mW/cm² for 100 minutes; a retrolental temperature of 41 °C was necessary to be achieved. When the eye temperature was kept low by external cooling, cataracts were not produced by higher field intensities; [31,32]that supports the hypothesis of a thermal mechanism being involved.^[15]

Sensory nerves are particularly sensitive to microwave damage. Cases of persistent neuritis and compression neuropathy were reported after significant microwave exposures.^[7]

When the temperature of the brain is raised to or above 42 °C, the blood–brain barrier permeability increases.^[15]

A neuropathy due to peripheral nerve lesion, without visible external burns, can occur when the nerve is subjected to microwaves of sufficient power density. The damage mechanism is believed to be thermal. Radiofrequency waves and ultrasound can be used for temporary blocking of peripheral nerves during neurosurgical operations.^[16]

The thermal effects of microwaves can cause testicular degeneration and lower sperm count.^[14]

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Pulmonary burn can be present when lungs are exposed; chest x-ray is used for diagnosing.^[11]

Exposure of abdomen may lead to bowel obstruction due to stenosis of the affected bowel; flat and upright abdominal x-ray is used to check for this condition.^[11]

Household microwave ovens have shielding around the inside of the oven that prevents microwaves from leaking out, as well as safety interlocks that prevent the oven from operating when the door is open. Therefore, burns due to direct exposure to microwave energy (as opposed to touching hot food) should not occur under normal circumstances.[33,34]

IV.CONCLUSIONS

Dielectric heating (diathermy) is used in medicine; the frequencies used typically lie in the ultrasonic, shortwave, and microwave ranges. Careless application, especially when the patient has implanted metal conductors (e.g. cardiostimulator leads), can cause burns of skin and deeper tissues and even death.^[24]

Microwave damage to tissues can be intentionally exploited as a therapeutic technique, e.g. radiofrequency ablation and radiofrequency lesioning. Controlled destruction of tissue is performed for treatment of arrhythmia.^[25] Microwave coagulation can be used for some kinds of surgeries, e.g., stopping bleeding after a severe liver injury.^[26]

Microwave heating seems to cause more damage to bacteria than equivalent thermal-only heating.^[27] However food reheated in a microwave oven typically reaches lower temperature than classically reheated, therefore pathogens are more likely to survive.[35,36]

Microwave heating of blood, e.g. for transfusion, is contraindicated, as it can cause hemolysis and hyperkalemia.^[8]

Microwave heating is one of the methods for inducing hyperthermia for hyperthermia therapy.

High-energy microwaves are used in neurobiology experiments to kill small laboratory animals (mice, rats) in order to fix brain metabolites without the loss of anatomical integrity of the tissue. [37,38]The instruments used are designed to focus most of the power to the animal's head. The unconsciousness and death is nearly instant, occurring in less than one second, and the method is the most efficient one to fix brain tissue chemical activity. A 2.45 GHz, 6.5 kW source will heat the brain of a 30 g mouse to 90 °C in about 325 milliseconds; a 915 MHz, 25 kW source will heat the brain of a 300 g rat to the same temperature in a second. Special devices designed or modified for this purpose have to be used; use of kitchen-grade microwave ovens is condemned[39].^[28]

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