Hyperthermia therapy

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Introduction:

Hyperthermia therapy is a medical course of treatment in which body tissue is exposed to higher temperatures (up to 113°F). These high temperatures have been proven, through research and clinical trials, to damage and kill cancerous cells, with minimal injury to normal tissues.

History:

The use of heat to treat disease goes back to ancient times. Ancient Greek physicians recognized the therapeutic value of fever, and for that purpose, hot water and sand (mud baths) and hot air and steam occurring in volcanic caves were utilized. The first known use of heat treatment was carried out by an Egyptian named Imhotep (2655 – 2600 B.C.). The ancient Egyptians used the so-called "fire drills" (hot blades and sticks) for the treatment of breast cancer. In the nineteenth century several German physicians observed regression or cure of sarcomas in patients who suffered prolonged high fevers due to infectious diseases. German physicians have been using whole-body hyperthermia treatment for over 80 years with well-established clinics now attracting patients from all over the world. Whole body hyperthermia is now being researched in depth, and being used all over the world to treat cancer, most notably in Germany. Published data worldwide has proven remarkable results and is indeed saving lives.

Importance:

Hyperthermia is used to shrink tumors due to its effectiveness in killing cancer cells and damaging proteins and structures within the cells. It can also make cancer cells more sensitive to effects of radiation or harm other cells that radiation cannot damage (when used in radiation therapy) and enhance effects of specific anti-cancer drugs. It is often used as a primary treatment of cancers, but it is applied as an adjunctive therapy with different established cancer treatments, including radiotherapy and chemotherapy.

Mechanism of Regulation:

In order to reach the desired temperature without exceeding it, the temperature of the tumor and the surrounding tissue is monitored throughout the duration of treatment. To monitor the temperature, doctors insert small needles or tubes with tiny thermometers into the treatment area, under local anesthesia. To ensure the proper positioning of the probes, imaging techniques such as computed tomography, may be used.

Mechanism of Action:

Hyperthermia provides intense heat that causes the denaturation and the coagulation of cellular proteins, which rapidly kills the cells of the tumor. It leads to slowed cell division and increased sensitivity to ionizing radiation therapy, which helps in treatment of the tumor. Hyperthermia also increases the pore size to improve delivery of large chemotherapeutic and immunotherapeutic molecules and the cellular uptake of small molecule drugs.

Local hyperthermia basically causes the blood vessels to the tumor to dilate, increasing the oxygen supply to the tumor, and this makes radiation therapy more effective. Oxygen is a potent radio sensitizer, meaning it increases the effectiveness of a given dose of radiation by forming DNA-damaging free radicals. Also, the increased oxygen supply to the tumors prevents cells from repairing the damage induced during the radiation session. Increasing the blood flow to the heated area, doubles the perfusion, which also enhances the delivery of medications. Hyperthermia, with really high temperatures (above 50°C) are used for direct destruction of some tumors. This generally involves inserting a metal tube directly into the tumor, and heating the tip until the tissue next to the tube has been killed.

Types:

There are several types of hyperthermia therapy, categorized as local, regional, and whole-body hyperthermia.

1. Local hyperthermia: During local hyperthermia, heat is applied to a small, specific area, such as a tumor. Among the different kinds of energy used to apply heat to the tumor are microwave energy, radiofrequency, and ultrasound energy.

Local hyperthermia uses various approaches depending on where the tumor is located. If the tumor is in or just below the skin, external applicators are positioned around or close to the region. The energy is focused on that area to raise the temperature of the tumor. If the tumor is within or near a body cavity, such as the esophagus or rectum, probes are positioned inside the cavity and inserted directly into the tumor to deliver heat. These methods are called intraluminal or endocavitary approaches. If the tumor is deep within the body, such as in the case of a brain tumor, interstitial techniques are used. Under the influence of anesthesia, needles or probes are inserted into the tumor. When it is properly positioned, the heat source is inserted into the probe. An example of interstitial hyperthermia is radiofrequency ablation. Radiofrequency ablation uses radio waves to heat and kill cancerous cells.

2. During regional hyperthermia, varying methods are used to heat large areas of tissue, like body cavities, organs, or limbs.

Deep tissue approaches are used to treat cancers such as cervical or bladder cancer. External applicators are situated around the body cavity or the organ that will be heated, and then microwave or radiofrequency energy is focused on that area in order to increase its temperature. During regional perfusion, some of the patient’s blood is removed, heated, and then perfused back into the limb or organ. This technique can be used to treat cancer in the arms and legs, such as melanoma, or cancer in organs such as the liver or lung. During continuous hyperthermic peritoneal perfusion, the heated anticancer drugs flow from a warming device through the peritoneal cavity, raising its temperature considerably. This is used to treat cancers within the peritoneal cavity, including primary peritoneal mesothelioma and stomach cancer.

3. Whole-body hyperthermia is used to treat metastatic cancer that has spread throughout the entire body. It combines several techniques to raise the body temperature. These techniques include thermal chambers that are similar to large incubators, or hot water blankets.

Advantages:

The effectiveness of hyperthermia therapy depends on the characteristics of the tissue being treated, the length of the treatment, and the temperature reached during the treatment.

Hyperthermia on its own has proven the ability to effectively treat cancer. In addition to that, it significantly increases the effectiveness of other treatments when they are combined. An example of that would be a combination of radiation and hyperthermia. When combined with radiation or within an hour of radiation therapy, hyperthermia is effective at damaging acidic, poorly oxygenated areas of a tumor and cells that are preparing to divide. Hyperthermia has been used to treat patients with early stages of breast, head, neck, and prostate cancer. When combined with radiation, hyperthermia has shown an improved response of 18% in effectiveness of the treatment of breast cancer. Significant clinical responses to hyperthermia have been found in treatment of melanoma and skin cancer, soft tissue sarcoma, bladder, cervical, rectal, axilla, and chest wall cancers.

Disadvantages/ Complications:

Normal tissues are not damaged during hyperthermia in general if the temperature remains under 111°F. However, due to regional differences in tissue characteristics, some tissues will show higher temperatures. This can result in burns, blisters, discomfort, or pain. Also perfusion techniques can cause tissue swelling, blood clots, bleeding, and other damage to the normal tissues in the perfused area. It is important to note though that most of these side effects are only temporarily.

Whole body hyperthermia can cause more serious side effects, including cardiac and vascular disorders, but these effects are uncommon. Diarrhea, nausea, and vomiting are also commonly observed after whole-body hyperthermia

Ongoing research/ Future of hyperthermia therapy:

Although hyperthermia therapy has proven to effectively treat various cancers, it is not considered a standard treatment for cancer. There are numerous clinical trials being administered in order to evaluate the effectiveness of hyperthermia and assess whether it has overcome certain challenges, such as achieving a uniform temperature in a tumor, or being able to precisely monitor temperatures of the tumor as well as the surrounding tissue. These studies vary in focus from improving hyperthermia techniques, investigating devices to measure total dose of heat received, to researching its effectiveness in combination with other cancer treatments. An example of clinical trials

in which hyperthermia therapy has proven successful is regional hyperthermia in combination with chemo radiotherapy to treat locally advanced adenocarcinomas of the middle and lower rectum. The combination therapy yielded acceptable toxicity and proved successful in rates of sphincter sparing surgery.

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