MAGNETO CALORIC HYPERTHERMIA (MCH) FOR CANCER TREATMENT

NAME OF THE PARTICIPANTS:

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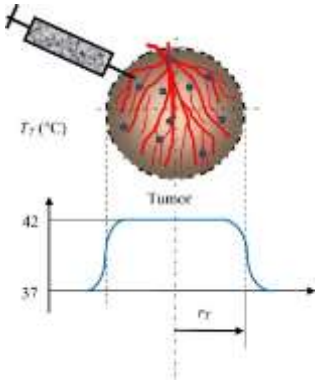


AIM:

To create awareness among the health care industry and also the public about Magneto Caloric Hyperthermia, a cost effective alternate to radiation therapy and magnetic hyperthermia used for cancer treatment. Our project is a **research based innovative project.**

SCIENTIFIC PRINCIPLES USED:

Magneto Caloric Effect – Heating/Cooling of a magnetic material in the presence/absence of magnetic field.

COMPONENTS USED:

FOR PRTOTYPE:

- Raspberry Pi 3
- Temperature sensor(DS18B20)
- Motor
- LED

INTRODUCTION:

Cancer is the deadliest disease in the world today. There are various treatments available for it. The most commonly known treatments are Radio therapy, Chemo therapy and anti-cancer drugs that have been in use over a long period of time.

As all of us know that radiation therapy is widely used for treating cancer but the **disadvantage** of radiation therapy is that it causes damage to the healthy human cells. Hence to avoid radiation therapy, scientists have made an attempt to treat the cancer with magnetic nanoparticles, which is known as Magnetic Hyperthermia.

An increase in the local temperature to values between 40 and 45 °C is sufficient to negatively impact cancer growth. Magnetic Hyperthermia is one of the cancer treatment methods that takes the advantage of the fact that cancer cells are more sensitive to temperature than normal cells.

In Magnetic Hyperthermia, magnetic nanoparticles are placed in **alternating magnetic fields** of a few gauss and they produce heat due to **magnetic relaxation losses**. Thus, the magnetic nanoparticles behave as a Nano-heater and its temperature increases, which can be used to kill the cancer cells.

However, the drawback in magnetic hyperthermia is the **lack of control of temperature** and **high dosage** , which may again damage

the healthy cells in the body and lead to side effects like nausea, back pain, chest pain etc.

One of the most **recent advancements** in the oncology field is **Proton Beam Accelerator Therapy** which is an expensive treatment (Rs. 15 lakh per treatment) that a common man cannot afford.

In our research study we are focusing on finding out a cheap yet effective solution for cancer treatment, and our project, Magneto Caloric Hyperthermia (MCH), is one among them.

The basic Principle of the **Magneto Caloric Hyperthermia** is **Magneto Caloric effect**, according to which a magnetic material heats and cools with the application and removal of a magnetic field respectively.

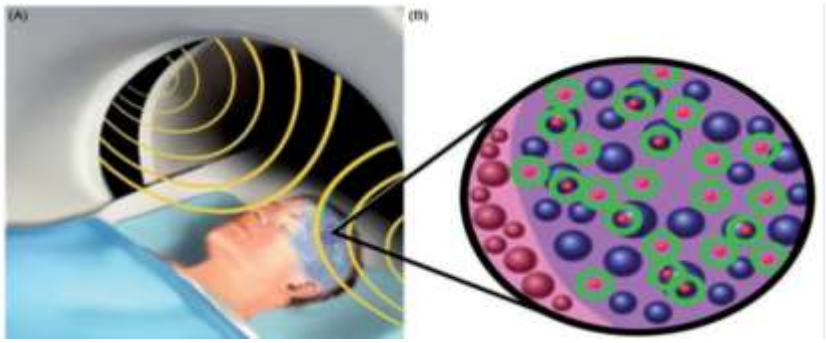
WORKING OF MCH:

Every cancer hospital has MRI, which is used to identify the tumor cells in the body. MRI has an **in built** magnetic field, which is sufficient to increase the temperature of magneto caloric materials. One can select a magneto caloric material with **Curie temperature** near the therapeutic range (i.e. 42 -46 °C) required to destroy cancer cells.

If we inject a magneto caloric material near the tumor region and apply the magnetic field (i.e. bringing the patient inside the MRI), the temperature of the magneto caloric material increases to the **targeted temperature**, there will not be any overshoot of temperature and this temperature will be maintained as long as the patient is inside the magnetic field (i.e. MRI). After the magnetic field is removed (i.e. bringing the patient outside the MRI) the material cools down immediately. Thus, the magneto caloric materials act as

heat switches and can be effectively used for both heating and cooling in human body.

Gadolinium salts [Gd-Si] exhibits magneto caloric effect and they can be used for treating the patients and they are biocompatible. After giving MCH, we should monitor the patient. The dosage depends on several factors like patients' age, weight, stage of the tumor etc.



DETECTING TUMOR IN MRI

The entropy of the **Magneto Caloric Material** can be given by the equation:

$$S_T(H,T) = S_M(H,T) + S_L(T) + S_E(T)$$

Where S_T is the total entropy and S_M, S_L, and S_E are magnetic, lattice and electronic entropy respectively.

When a magnetic field is applied adiabatically, the magnetic moments get oriented and there will be a reduction in the S_M. The reduction in S_M will be represented by an increase in the lattice entropy S_L and as a result temperature of the system will rise. The temperature will remain constant and entropy will reduce if the magnetic field is applied isothermally.

Entropy change and adiabatic temperature change can be calculated by the Maxwell relation:

$$\Delta S_M(T,\Delta H) = \int_0^H (dM/dT)dH$$

Adiabatic Temperature Change:

$$\Delta dT = -(T/C_H)(\partial M/\partial T)_H \, dH$$

Where S is the entropy, H is the applied magnetic field, M is the magnetization, T is the temperature and C is specific heat.

WORKING OF THE PROTOTYPE:

For our prototype we have used a model of a lung which is cancerous. It consists of 2 sections; section A is the region that houses the healthy cells and section B consists of the tumor cells. Each sensor lead represents an individual Nanosensor. One of which is placed in section A and the other is placed in section B. These sensors sense the temperature of each region and report it back to the brain of the system - The Raspberry Pi

These sensors are connected to a microcontroller called the Raspberry Pi. The Raspberry Pi is a minicomputer which has been programmed in Python.

Hot/Warm water has been added to the cancer cell to represent the heat that would be produced by the gadolinium salt when it is exposed to a DC magnetic field. Once the sensor in section B reaches the Curie temperature, it begins to spread to section A as well. As section A reaches the Curie temperature the cooling process for section A begins (i.e. water pump turns on) which represents the gadolinium returning to room temperature when the magnetic field is removed. Each of the sensors also has LED indicators (one blue and one red). The blue LED remains on while the temperature is normal (body/room temperature). Once a sensor reaches the Curie temperature its corresponding red LED turns on.

ADVANTAGES:

- **A few milligrams of dosage is required** – when we compare it with the dosage of drugs given in chemotherapy and magnetic hyperthermia, in MCH only a few milligrams is required. Because of the higher dosage in chemotherapy and magnetic hyperthermia the heat absorbed by the healthy cells causes a lot of side effects.

- **Human compatible** – In patients with normal renal function gadolinium elimination is thought to be rapid and complete.

- **Even a common man can afford this treatment**. In case of proton beam therapy, a single treatment costs Rs 15 lakhs (as mentioned in the interview) which an economically above average person cannot afford.

- **Only DC magnetic field is required**. For Magnetic Hyperthermia, AC magnetic field is mandatory.

- **Cost effective** – each treatment of MCH costs approximately Rs 8000 to Rs 10000. Whereas all other treatments are very costly.

- To give **MCH treatment**, there **is no need to do extra set up** of lab / medical room. This is not the case in all other techniques.

TOTAL COST: Rs 8000 to Rs 10000 per treatment.

INTERVIEW AND SURVEY:

We have interviewed Dr. Anitha G, senior consultant, Apollo hospital, Bangalore to know about the dosage used, time period and side effects and other implications caused by radiation therapy, chemotherapy, Magnetic Hyperthermia and Proton Beam Therapy. A questionnaire was prepared for doctors and medical personnel. The aim of the questionnaire was to better understand the ongoing treatments and their implications on the patients. It is a need of the hour to implement MCH to save cancer patients.

The questionnaire was distributed among known doctors and medical personnel. It was made sure that the doctors returned back the questionnaire with all the questions answered and with a paper seal to authenticate the document. A total of 5 survey reports were collected and the following inferences were made.

INFERENCES FROM SURVEY:

- 80% of doctors want MCH to be implemented on a large scale and have validated that such a treatment is immensely useful.
- 100% of doctors want a method of treatment with less side effects and cost effective.

FUTURE SCOPE:

This is an innovative research based project. As a future scope, this could be implemented by doctors on experimental basis and we hope it is the need of the hour to implement MCH to save cancer patients.