# Heat and Cold in Medicine

# INTRODUCTION

Heat and cold have been used for medical purposes for several thousands years. Galen, an ancient physician, recommended the use of warm water and oil in some treatments, and the application of cold substances on injuries was urged by another early physician. Throughout the ages, controversy on the therapeutic value of heat and cold has existed. Even today there is much to be learned about these two treatment methods. Much of the progress in this area of medical physics as in many others has been due to the cooperation and collaboration of basic scientists and physicians.

Heat Therapy

Two Primary therapeutic effects take place in a heated area:

1. There is an increase in metabolism resulting in a relaxation of capillary system, vasodilatation).
2. There is an increase in blood flow as blood moves it will cool the heated area.

The increase in tissue temperature increases the blood flow and also increases the cell membrane permeability and fluidity and hence leads to the increase of cellular metabolism, which in turn will increase the oxygen demand and food stuffs.

Methods of applying heat
to the body

- Conductive heating.
- Infrared (IR), radiant heating.
- Radiowave heating (diathermy).
  - Short Wave, $\lambda = 10$ m
  - Microwave, $\lambda = 12$ cm
- Ultrasonic wave heating (Ultrasonic diathermy).

1. The conductive method:

The conductive method is based on the physical fact that if two objects at different temperatures are placed in contact, heat will be transferred by conduction from the warmer object to the colder one.
The total heat transferred will depend upon:

1. The area of contact.
2. The temperature difference.
3. The time of contact.
4. The thermal conductivity of the material k.

Conductive heat transfer leads to local surface heating, since the circulating blood effectively removes heat that penetrates deep into the tissue. Hot baths, hot packs, electric heating pads, and occasionally hot paraffin wax are applied to the skin to heat the body by
conduction.

Conductive heating is used in treating conditions such as:

- Arthritis.
- Sprains.
- Contusions
- Back pain.
- Neuritis.
- Strains.
- Sinusitis.

## 2. Radiant Infrared (IR) heat:

Radiant infrared (IR) heat is also used for surface heating of the body.
This is the same form of heat we feel from the sun or from an open flame.
Man made sources of radiant heat are:

- Glowing wire coils.
- 250 watts incandescent lamp.

The IR wavelengths used are between 800 and 40,000 nm.

- The waves penetrates the skin about 3 mm and increase the surface temperature.

# Caution!!

Excessive heating of tissue causes reddening (erythema) and somewhat swelling (edema), very prolonged heating of tissue causes browning and hardening of the skin. Radiative heating is generally used for the same conditions as conductive heating, but it is considered to be more effective because the heat penetrates deeper

3. Radiowave Heating (Diathermy):

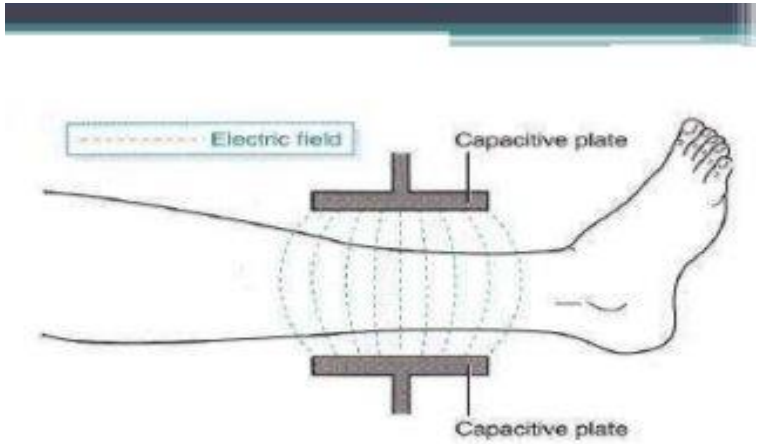
The amount of heat that can be transferred to the body by electrical diathermy increases as the frequency of the current increases.

- Short-wave diathermy utilizes electromagnetic waves in the radio range (wavelength ~ 10 m).
- Microwave diathermy utilizes electromagnetic waves in the radar range (wavelength ~ 12 cm).
- Heat from diathermy penetrates deeper into the body than radiant heat and conductive heat.
- It is thus useful for internal heating and has been used in the treatment of inflammation of the skeleton, bursitis and neuralgia.

Methods used for transferring the electromagnetic energy into the body:

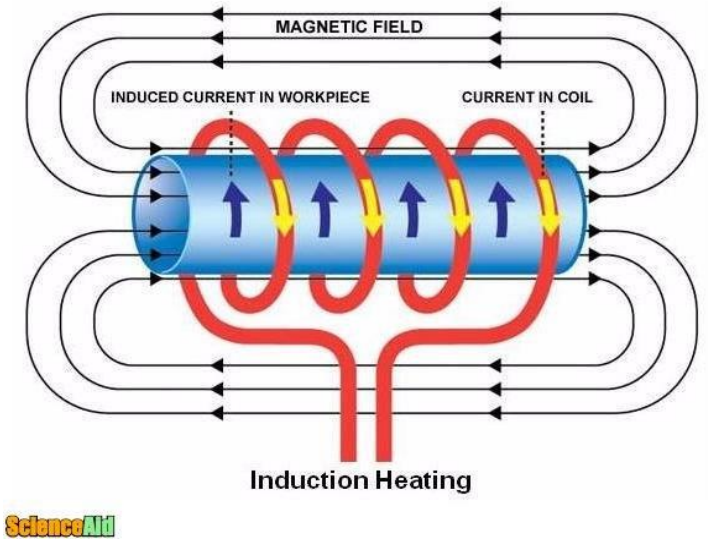
1. Capacitance Technique:

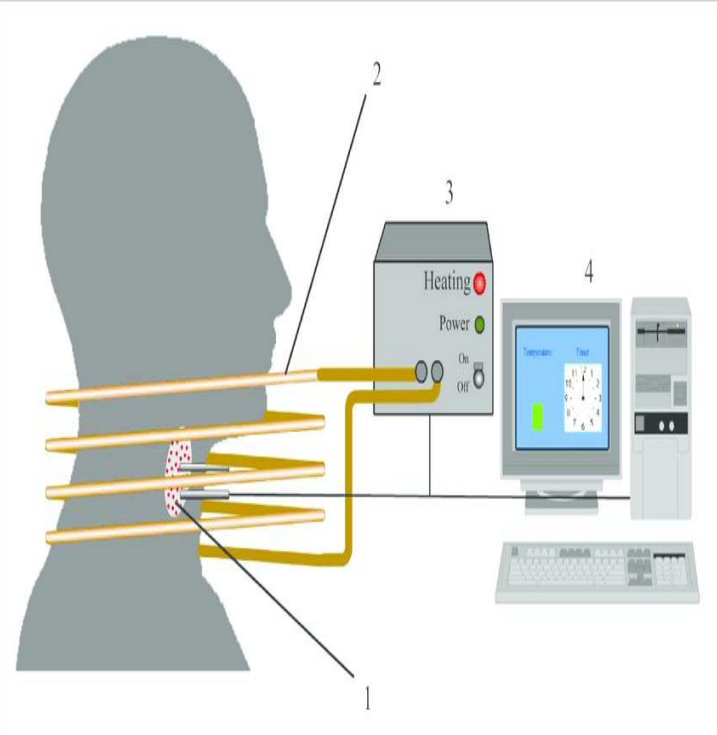
The part of the body to be treated is placed between two metal plates.
The body tissue between the plates acts like an electrolytic solution.
This will result in resistive heating.



# 2. Magnetic induction technique:

In induction diathermy, either a coil is placed around the body region to be treated or a “pancake” coil is placed near the part to be treated of the body.
The alternating current in the coil results in an alternating magnetic field in the tissue producing joule heating in the body to be treated.



# 3. Microwave diathermy:

- Microwave is another form of electromagnetic waves.
- It is easier to apply than short-wave diathermy.
- Microwave diathermy developed out of radar research.
- It is produced in a special tube called a magnetron and are then emitted from the applicator (antenna). The antenna is usually designed so that it can be placed several inches from the regionto be treated.
- The microwaves from the antenna penetrate deep into the tissues, causing a temperature rise and deep heating.
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The frequency used in microwave diathermy is 2450 MHz because this frequency was the one available after world war II.

Later research has shown that a frequency closer to 900 MHz would be more effective in therapy, causing more uniform heating around bony regions.

4. Ultrasonic diathermy:

- They are also used for deep heating of body tissue. These waves are completely different from electromag. waves, just discussed. They produce mechanical motion like audible sound waves except the frequency is much higher (usually near 1 MHz).
- In ultrasonic diathermy, power levels of several watts per cm2 are usually used and the sound source is directly in contact with the body. As it moves through the body, the particles in the tissue moves back and forth. The movement is similar to a micro-massage and results in heating of the tissues.

Ultrasonic heating has been found useful in relieving the tightness and scarring that often occur in joint disease and it greatly aids joints that have limited motion. It is useful for depositing heat in bones because they absorb ultrasound energy more effectively than does soft tissue.

## Use of Cold in Medicine:

**Cryogenics:**

It is the science and technology of producing and using very low temperatures.

**Cryobiology:**

It is the study of low temperature effects in biology and medicine.

**Cryonics:**

It is the science of using cryogenic methods to cool the body into a state of “suspended animation” so that it can pass a time without aging. One goal of cryonics is to preserve people with fatal diseases at low temperature with hope that in the future they could be revived and their diseases cured.

# Cryogenics and Preservation of Tissues

Considerable effort has been expanded on the problems associated with the preservation and storage of various tissues. It is found that, preservation is much better at the temp.of liquid nitrogen (-196 ºC) than at the temp. of solid carbon dioxide (-79 ºC).

- It is very important to note that survivals after freezing is more dependent upon the cooling rate during the freezing cycle than on the warming rate during the thawing cycle.

## Blood Preservation:

- By adding a protective agent such as glycerol or dimethyl sulfoxide before cooling. The use of additives to enhance survival sometimes presents problems that are more complicated than the original ones involved with the freeze-thaw cycle. For example, the removal of glycerol from blood is sufficiently complicated to limit the process to a few large hospitals.
- The conventional non-cryogenic method of blood storage involves mixing the whole blood with an anticoagulant and storing it at 4 ºC. About 1 % of the red blood cells hemolyze (break) each day, so that the

Blood can be stored for much longer time if it is rapidly frozen. Two techniques are used for this Thin-walled containers:

A thin walled container after it is filled with blood it is quickly inserted into a liquid nitrogen bath and the blood by this method can be stored indefinitely at -196 ºC.

## Blood sand method:

Blood is sprayed onto a liquid nitrogen surface and freezes into small droplets. The droplets are about the size of grains of sand-hence the name “blood-sand”. The droplets are collected and stored in special containers usually at the temperature of liquid nitrogen, -196 ºC.

## Organ preservation:

Experimental wok is under way to form banks for skin, bone, muscles, and organs. These substances are harder to preserve than simple cells such as red blood cells for a number of reasons;

- The large physical dimensions limit the cooling rate.
- Adding or removing protective agents is difficult.

Even so, some work has successfully been carried out with cornea and skin preservation. Organ preservation and re-use is still in the experimental stage.

## Cryosurgery:

It is the usingof cryogenic methods to destroy cells, which has many advantages as follow;

- There is a little bleeding in the destroyed area.
- The volume of the tissue destroyed can be controlled by the probe.
- There is a little pain sensation because low temperature desensitizes the nerves.

- **Usage of Cryosurgery:**

**Treatment of Parkinson's disease (shaking palsy).**

The treatment can be done by destroying the defected cells in the thalamus. The tip of the probe is cooled down to -10 ºC and moved into the appropriate regions of the thalamus, causing temporary freezing of these regions, where the
surgeon can observe when shaking stops; this means that the probe has reached the correct region of the thalamus. This region is destroyed by freezing for several minutes at temperatures near – 85 ºC.

## Treatment of detached Retina and Cataract

surgery;

Due to an accident the retina become detached from the wall of the eyeball. This will produce a blurred spot in the vision because the light rays are not focused at the correct spot. If a cold tip is applied to the outside of the eyeball in the vicinity of the detachment, a reaction occurs that acts to weld the retina to the wall of the eyeball.

For Cataract (darkened lens), the cold probe is touched to the front surface of the lens, making the lens easy to remove.

## Treatment of Tumors and Warts;

Cryosurgery can be used in destroying the tumors cells and infected cells.

## Caution !!!

Caution should be taken when using these cryogenic materials because;

Its contact with the eye or skin will cause “freeze burns”.

The most care is required when Oxygen is used because it is greatly enhances combustion, where many materials that do not burn in air will burn in pure oxygen.