The Four lecture : Heat and Cold in Medicine

Heat : It is the energy transferred from the hot subject to the cold subject causing to rise the temp of cold subject.

As molecules of all materials are moving so they have kinetic energy. The average kinetic energy of an ideal gas can be shown to be directly proportional with temperature. The same thing is for liquids and solids .The movement of gas molecules are more free than liquid and liquid molecules are more free than solid , an increase of temp. of any material means an increase in the energy of molecules of that material.

In order to increase the temp. of a gas it is necessary to increase the average kinetic energy of its molecules by putting the gas in contact with a flame , the energy transferred from the flame to the gas causing temp. rise is called heat. If enough heat added to a solid, it melts, forming a liquid. The liquid may be changed to a gas by adding more heat. Adding still more heat converts gas to ions. While adding heat to substance increase its molecular kinetic energy, which increase its temp., the reverse is also true, heat can be removed from a substance to lower the temp., Low temp. referred to as the cryogenic region (absolute zero,-273.15°c).

The Ways To Measure The Body Temperature :

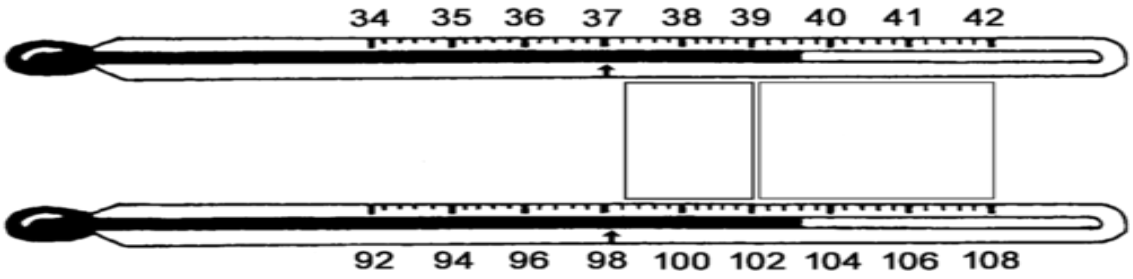
a- Glass Fever Thermometer :

This is **defined** as thermometer composed of glass capillary tube ends with a bulb (a store for liquid) . The liquid can be Mercury or Alcohol .

The **principle** behind thermometer is that an increase in the temperature of different materials usually causes them to expand different amounts . So a temperature increases causes the alcohol or mercury to expand more than

the glass and thus produce an increase in the level of the liquid . The expansion of the liquid in a thermometer is not large -1 cm^3 of mercury increases in volume by only 1,8 % in going from 0 to 100 C .

As the fever thermometer is needed to be precise , it has a thin capillary less than (0.1 mm) in diameter , which makes the mercury to rise higher per degree . In addition to that the fever thermometer has **a restriction** above the bulb making the mercury not to return if the thermometer is exposed to low temperature . In the fever thermometer , Two things increase the visibility of the capillary : the glass case acts a magnifying glass and opaque white backing is used .



b- The Thermistor

It is a special resistor that changes its resistance rapidly with temperature (5% C) . As shown in the figure below , four resistors form the bridge are equal , that is , the bridge is balanced . A temperature change causes the thermistor resistance to change. Thermistor are used quite often in medicine because of their sensitivity .

The thermistor **advantages** :

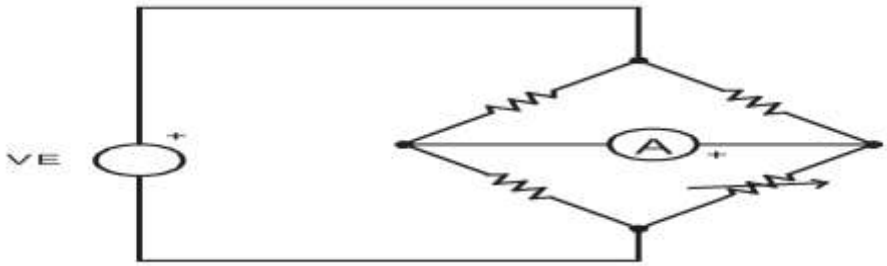
1-Changes rapidly with temperature .

2-Very sensitivity , it is easy to measure temperature changes of (0.01 C) .

3-Small mass , thermistor has little effect on the temperature of the surrounding tissues .

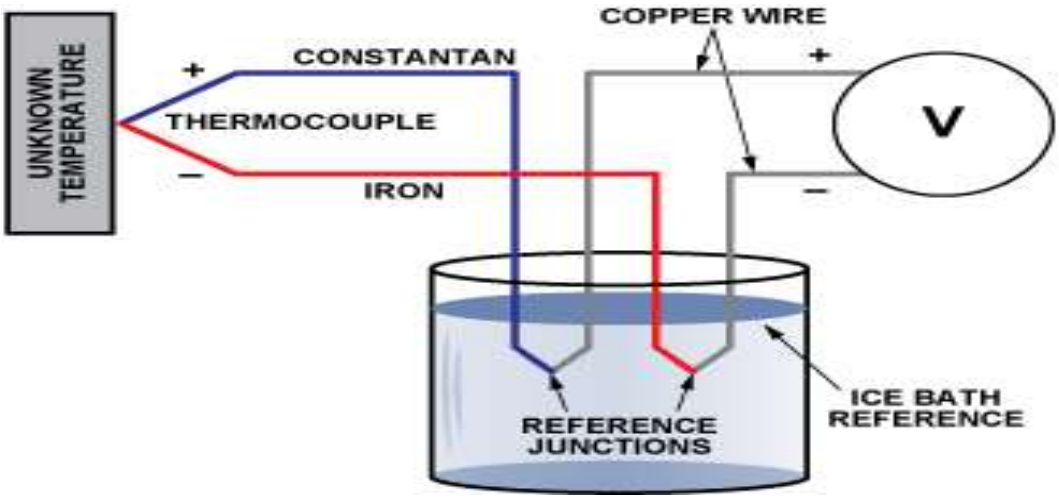
4-The meter can be located some distant from the patient .

5-Breathing rate temperature measurement , (Pneumograph) .



c- The Thermocouple .

A Thermocouple consists of two junctions of two different metals . If the junction are at different temperatures , a voltage is produced that depend on the temperature difference , usually one of the junction is kept at a reference temperature such as in an ice – water bath . The copper – constantan thermocouple shown in figure below can be used to measure temperature from (– 190 to 300 C) . For a (100 C) temperature difference , the voltage produced is only about (0.004 V) (4 mV) .Thermocouples can be made small enough to measure the temperature of individual cells .



Thermography :

It **is** mapping the bodys temperature . Measurements of body surface temperature indicate that the surface temperature varies from point to point depending upon :

a-external physical factors

b-internal metabolic

c-circulatory process near the skin

Thermography also can be used in :

a-aid in detecting other types of cancer

b-study the circulation of blood in the head

c-reduce leg amputations in diabet

Two different methods are used for transferring the electromagnetic energy into the body in short wave diathermy.

A- In one, the part of the body to be treated is placed between two metal plate like electrodes energized by the high –frequency voltage. The body tissue between the plates acts like an electrolytic solution. The charged particles are attracted to one plate and the other depending upon the sign of the alternating voltage on the plates: this results in resistive heating.

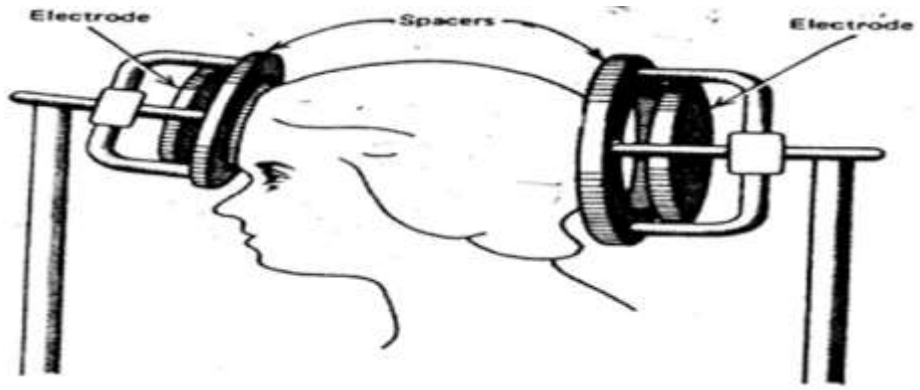


Figure -Location of capacitor plates for short wav diathermy.

B- The second method of transferring short wave energy into the body is magnetic induction. A coil is placed around the body region to be treated. The alternating current in the coil results in an alternating magnetic field in the tissue, producing joule heating in the body region being treated. It has been used in relieving muscle spasms, pain from protruded intervertebral discs, joint disease.

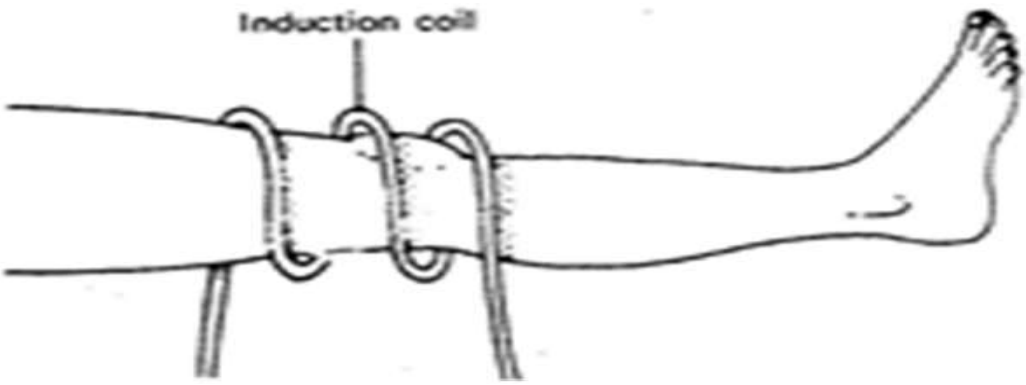


Figure- Location of induction coil around knee for short-wave.

Use of Cold in Medicine :

Cryogenics is the science and technology of producing and using very low temperature . The study of low temperature effects in biology and medicine is called (Cryobiology) .

Blood Storage

1- Conventional method :

It can be stored with anticoagulant at (4 C) . A bout (1 %) of the red blood cells (RBCs) hemolyze (break) each day so . the blood will not be suitable for use after (21) days. For rare blood types should be stored for longer periods , so other procedures were used.

2- Long term storage

Blood can be preserved for very long periods of time if it is frozen rapidly in liquid nitrogen (-196 C) . The rate of freezing is very important to revive the cell after thawing them . There are **two** ways to freeze the blood to (-196 C).

A-Blood sand method

In this method , the blood sprayed on the surface of liquid nitrogen and then it will frozen in small droplets in very short time forming sand like particles . The stored at liquid nitrogen temperature.

B-Thin wall method

The blood is kept in a thin wall highly conductive with large surface area metal container and the spacing between the walls of the container is also

small to maintain a small thickness of blood inside the container fig (4-13 P82) . The container with the blood is immersed into the liquid nitrogen making very rapid cooling.

Cryosurgery :

It is the use of cryogenic methods to destroy cells . It has several advantages :

a-Cause a little bleeding in the destroyed area.

b-The volume of the tissues destroyed can be controlled'

c-Little pain because low temperature tend to desensitize nerves .

d-Very short recovery time .

e-Successful results were obtained in more than 90 % of the cases.

The Stefan – Boltzman Law :

One very appealing method of obtaining a thermogram is to measure the radiation emitted from the body. The basic equation described the radiation emitted by a body was given by Max Plank in 1901 . For our purpose the Stefan – Boltzman law for the total radiative powere per surface area W is more useful . It is :

$W = e \sigma T^4$ Where : e : is depending upon the emitter material . For radiation from body **e** is almost **one**.

T : is the absolute temperature , E : is the emissivity

σ : the Stefan Boltzmann constant = 5.7×10^{-12} W/ $cm^2.K^4$

normal body temp =(T C^o+273) k ° (this temperature scale is not used in medicine).

Example :

a- what is the power radiated per square centimeter from skin at a temperature of 306 k ?

b- what is the power radiated from a nude body 1.75 m^2 in area ?

Example:

A person of skin temp. of 36C_o and body surface area 1.75m^2 .find :

1. net total power if he receives radioactive power from the surrounding walls $20C_o$ would be about 735w. ($\sigma = 5.7 * 10^{-12}$ w/cm^2)

2. The emissivity of surrounding walls.

Solution

1- T=36Cº+273=309 ºK

$W = e \sigma T^4$ $=1*(5.7*10^{-12})*(309)^4$

$=0.052$ w / cm^2

Total power (w)={Total radiative power per surface area}*surface area

$= 0.052$ (w/cm^2) * $1.75*10^4$ (cm^2)

= 910 w

$\therefore$ net power =910 - 735 = 175w

2- T= 20 + 273 = 293K

Heat from the wall = 735= [e* $5.7*10^{-12}$ *$(293)^4$] *** (1.75**10^4)

$\therefore$e = 735 / (735.163) = 0.998

Heat Therapy

Heat was recognized as therapeutic agent several thousand yearsago. It has two primary therapeutic effects:

1-An increase in metabolism resulting in relaxation of the blood capillaries (vasodilation).

2-An increase in blood supply to cool down the heated area.

Physical Methods of Producing Heat in the Body

1- Conductive heating.

2- Infrared radiant heating (IR).

3- Radio wave heating (Electro magnetic Wave).

4- Micro wave diathermy .

5- Ultrasonic wave heating.

1. Conductive Heating : → used to treatment the superficial area.

*** Conductive Heating** is used in treating conditions such as **:-**

1- Arthritis. 2- Neuritis. 3- Sprains. 4- Strains. 5- Contusions.

6- Sinusitis. 7- Back Pain.

2. IR. Heating:

The heat can be transferred to the body by radiation. It is used for surface heating of the body .This is the same heat. We feel from the sun and flame.

 The IR wave length used are between (800- 4000nm).

 These wave penetrate the skin about (3mm)& increase the surface temp.

 This type of heating is used to treat the same conditions of conductive heating.

3. Electromagnetic Wave (diathermy).

They are very useful for internal heating because E.M.R. have energy depend on their frequency $E=h\gamma$, (γ : is the frequency).

A. Short wave diathermy(*Wavelength (λ) = 10nm & F=30 MHz*) :

Heat from diathermy is useful for internal heating because it penetrates deeper than radiant & conductive heat.

 It used in treatment of :

A. In flammation of the skeleton , bursitis , neuralgia .

B. Muscle spasm, pain from intervertebral discs , joint disease.

 The treatment is done by two method to get energy to the part of The body :

1- Capacitance method.

Heat = Constant × (current)^2

2- Magnetic induction.

B. Long Wave Diathermy : The frequency = 10 kHz .

EM Diathermy has limitations when it used on muscle tissue surrounded by fatty layer. In infrared waves most of the energy is deposited in the surface of fatty layers. So, we use microwaves diathermy for deep area covered with fatty layers.

4. Microwave Diathermy : F= 2460 MHz

It is penetrate deep into the tissue → causing temp . rise & deep heating.

* **Microwave therapy is used in the treatment of** :

1. Fractures. **2**. Sprains. **3**. Strains . **4**. Bursitis. **5.** Arthritis. **6**. Injuries to tendons.

*** The absorption for homogeneous tissue can be described by this equation:**

$$I = Io\ e^{-x/D}$$

I : radiation intensity at the depth **X** in the tissue.

Io : radiation intensity at the surface .

X : depth in the tissue.

D : Tissue thickness at which 63% of the beam is absorbed.

Example:-

If the radiation intensity of the surface is 10^4 & tissue for treatment half of intensity absorbed at depth 3cm. Calculate the intensity under 2cm in tissue.

At the half value thickness ($X_{1/2}$) The beam absorbed Is

$I = Io/2 \rightarrow$ ie $I/Io = 1/2$ at $x = X_{1/2}$

Since $I = Io\ e^{-X/D} \rightarrow$ ie $I/Io = e^{-X/D}$

$\therefore\ 1/2 = e^{-X_{1/2}/D} \rightarrow Ln\ 1/2 = -X_{1/2}/D$

$Ln2 = X_{1/2} / D \quad \therefore \quad D = X_{1/2} / 0.693 = 3cm / 0.693 = 4.32cm$

To calculate the intensity under 2 cm in tissue substitute the value of intensity Io and D in equation

$\therefore\ I = 10^4\ e^{-2\ cm\ /\ 4.32} = 6.3 * 10^3$

Absorption of Microwave beam depend on :

1. The a mount of water in the tissue.

Because the energy is deposited more effectively in tissue with high water content, microwave energy is absorbed better in muscle tissue rather than in fatty tissue which have less water.

2. The frequency of microwaves:

Ultrasonic waves

These waves are different from electromagnetic waves. It produces mechanical vibration inside tissue. It is the same as the sound waves but it has much higher frequencies about 1MHz with power of several watts per centimeter. It can move the tissue particles backward and forward with high frequency, in doing so it can increase the kinetic energy consequently it heats the tissue. Ultrasound can be produced by special transducers placed in direct contact with the skin. It is used for reliving tightness and scarring occurring in joint disease. It can dispose more heat in bones, as bones are better absorber for ultrasonic energy than soft tissue. It is also used in deep therapy. Heat therapy has also been used in cancer treatment in combination with radiotherapy. The tumor is heated about 42°C for approximately 30 minutes, and the radiation treatment is given after heat treatment.