Al-Mustaqbal University

College of Technology and Health Sciences

Medical physics Department

Medical Physics

First Semester

3rd stage

Lesson 5

Heat and cold in medicine

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Physical Basis of Heat and Temperature

Matter is composed of molecules that are in motion. Gas and liquid molecules are moving and hitting one another; even in solid, molecules have some motion about the sites that occupy (Figure 1).

The fact that the molecules are moving means they have ***kinetic energy*** and this kinetic energy is related to temperature.

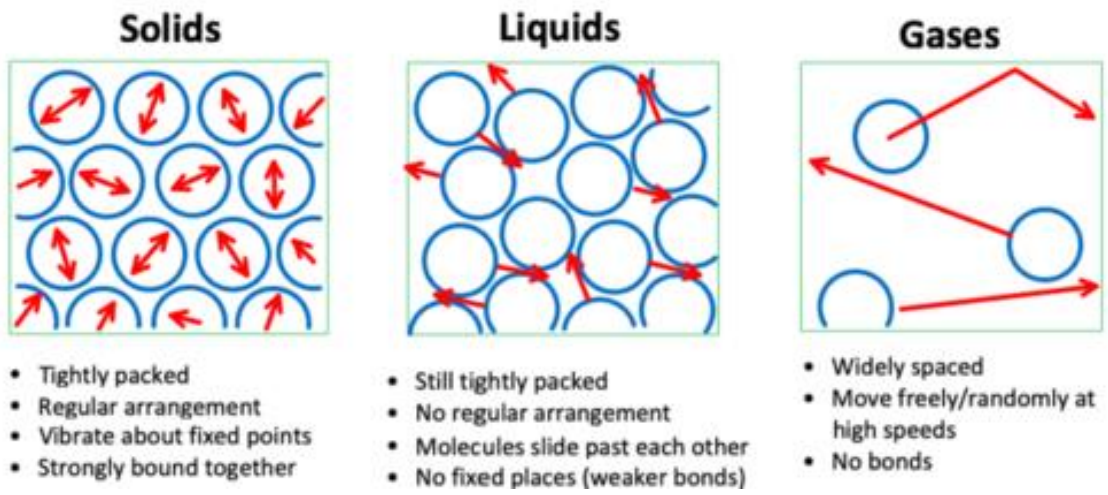

Figure 1. How molecules are arranged and moving

In order to increase the temperature of gas, the kinetic energy of its molecules should be increased.

This can be done by putting the gas in contact with flame. The energy transferred from flame to the gas causing the temperature rise is called ***heat.***

If enough heat is added to solid, it melts, forming liquid. The liquid may be changed to gas by adding more heat.

The reverse is also true; heat can be removed to make the temperature lower.

Thermometry and Temperature Scales

Different types of medical thermometers include:

Type	Working principle	Benefits	Drawback
Digital Thermometer 	• Work by using heat sensors that measure your body temperature.	• Inexpensive • Easy to use. • Fast and accurate • It can be used in mouth and armpit.	• You cannot use the same thermometer in mouth and armpit. • Batteries should be replaced frequently.
Tympanic Thermometer 	• Measure the temperature inside the ear canal through infrared ray technology.	• It takes only a few seconds to take a reading and saves a lot of time.	• 0.3 degrees Celsius to 0.6 degrees Celsius higher than the oral thermometer readings. • Earwax may skew results. • Not fit properly in a small or curved ear canal.
Forehead Thermometer 	• Use infrared sensors to measure the temperature of your Superficial Temporal Artery	• Quick readings • Require no physical contact. • Can be used on infants, children, and adults.	• 0.6 degrees cooler than the oral thermometers. • Can be affected by external factors, including wind, and direct sunlight.
Plasticstrip Thermometers 	• Placing the strip on your forehead to determine the temperature.	• Very simple to use. • Reasonable pricing	• Will inform you that you have a fever but will not provide exact temperature readings.
Mercury Thermometer 	• Putting it under tongue until the temperature rises. • The temperature increase causing the mercury expands.	• Doesn't require a battery to work. • Provide accurate reading • Can be used orally, or under your armpits. • Economical pricing.	• Since they're made from glass, mercury thermometers may break easily, allowing toxic mercury to escape.

Thermography-Mapping the body's temperature

Measurements of body surface temperature indicate that the surface temperature varies from point to point.

Since variations in temperature may be abnormal conditions, many researches have attempted to measure the surface temperature of the body and relate it to pathologic conditions.

The need for simple routine obtaining a surface temperature map ***(thermogram)*** was brought into focus by some studies done in the 1950s when it was found that most breast cancers could be characterized by an elevated skin temperature in the region of cancer. The surface temperature above the tumor was typically about 1° C higher than nearby tissue. So, a very sensitive temperature measuring device have to be used.

The method of obtaining ***thermogram*** is to measure the infrared radiation emitted from body which is invisible to see by human eye.

Infrared thermography is a powerful tool with the great potential of mapping the skin over large areas of the human body (figure 2).

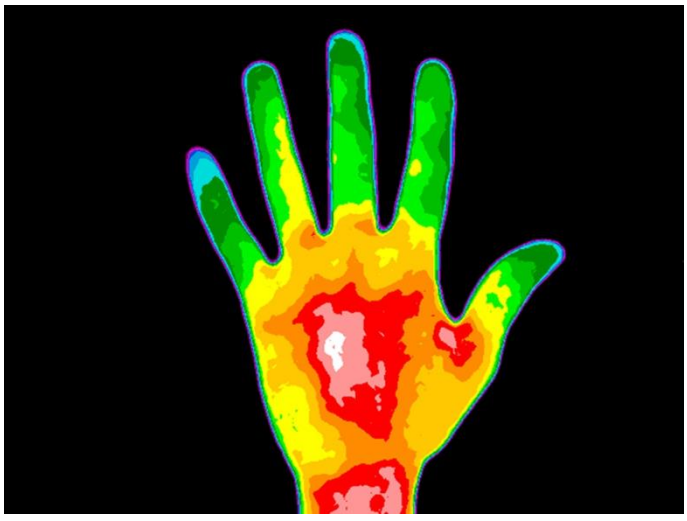

Figure 2. Infrared thermography

Stefan-Boltzmann law

The equation describing the radiation emitted by body is given;

$$W = e\sigma T^4$$

Where; W is the total radiative power per surface area, e is the emissivity which depends on the material, σ is Boltzmann constant (5.7×10^{-12} W/cm^2 K^4) and T is the absolute temperature (^{o}K). (^{o}K = ^{o}C + 273).

Now, the emissivity of the human body equals 1; thus by knowing the W then we can find the temperature.

Example:

A. What is the power radiated per square centimeter from skin at temperature of 306 ^{o}K (33 ^{o}C)?

$$W = e\sigma T^4$$

$$W = 5.7 \times 10^{-12} \times (306)^4 = 0.05 \text{ W/cm}^2$$

B. What is the power radiated from a body of 1.75 m^2?

$$W = (0.05)\ (1.75 \times 10^4) = 875 \text{ W}$$

Applications of Thermography;

- Breast pathologies
- Extra cranial Vessel Disease
- Neuromuscular-Skeletal
- Vertebrae (nerve problems/arthritis)
- Lower Extremity Vessel Disease

Heat Therapy

Two primary therapeutic effects take placed in a heated area:

1. Increase in metabolism → relaxation of capillary → vasodilatation.
2. Increase blood flow as blood moves to cool the heated area.

There are many methods of producing heat in the body:

Method	Principles	Usage
Conductive heating	Heat transfer from hot surface to the body by contact; such as; • Hot packs • electric heating pads hot paraffin	• Arthritis • Sprain • Sinusitis • Contusions • Back pain
Infrared heating	IR radiation penetrate the skin about 3mm	Used for the same conditions as conductive heating but it is more effective as the heat penetrate deeper
Radiowave heating (diathermy)	Radio wave is used to penetrate deeper into the body than IR	• Treatment of inflammation of the skeleton • Bursitis • Neuralgia
Ultrasonic wave	Also used for deep heating of body. As the ultrasonic wave move through the body, the particles in the tissues move back and forth.	Relief tightness and scarring that occur in joint disease

Use of cold in medicine

Cryogenic methods used to destroy cells & this applications called cryosurgery

Cryosurgery has several advantages:

1. There is minimal bleeding.
2. The volume of tissue destroyed can be controlled.
3. There is little pain sensation.

One of first use of cryosurgery was in treatment of ***Parkinson disease*** (shaking palsy). Parkinson disease (figure 3) causes uncontrolled tremors in the arms and legs, it is possible to stop tremors by destroying the parts of thalamus in the brain that control the transmission of nerve impulses to other parts of nervous system.

Figure 3. Parkinson's disease

Cryogenic method also used in several types of eye surgery we discuss two:

1. The repair of detached retina and cataract surgery (the removal of darkened lens)
2. In surgical extraction of the lens, a cooled probe is touched to the front surface of the lens, the probe sticks to the lens making lens easy to remove.

Much interest has been aroused by the idea of using cryogenic methods to cool the body into state of suspended animation so that it can pass time without aging. This science is called ***Cryonics***

One goal of cryonics is to preserve at law temperature people with fatal diseases with hope that in future by could be revived and their disease cured.Some simpler human biological system such as blood, semen and tissue have successfully been cooled, stored and revived.

Exercises

1 The fact that the molecules are moving means they have

(a) Kinetic energy

(b) Potential energy

(c) No energy

(d) Magnetic energy

(e) None of them

2 The energy transferred from flame to the gas causing the temperature rise is called

(a) Cold

(b) Thermogram

(c) Heat

(d) Temperature

(e) Thermometer

3 The thermometer that Use infrared sensors to measure the temperature is;

(a) Mercury thermometer

(b) Digital thermometer

(c) Tympanic thermometer

(d) Plasticstrip thermometer

(e) Forehead thermometer

4 The surface temperature above the tumor is higher than nearby tissue by about;

(a) 5 ^{o}C

(b) 4 ^{o}C

(c) 3 ^{o}C

(d) 2 ^{o}C

(e) 1 ^{o}C

5 Heating an area of a body

(a) Can cause severe damage in the tissue of heated area
(b) Increase blood flow to cool down the heated area
(c) Increase the cancer possibility in this area
(d) Increase pain in this area
(e) None of them