Medical Physics

Pressure

Lecture Four

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Pressure is defined as the force per unit area in a gas or a liquid. For a solid, the quantity of force per unit area is referred to as stress.

P = F/A

In a metric system, pressure is measured in units

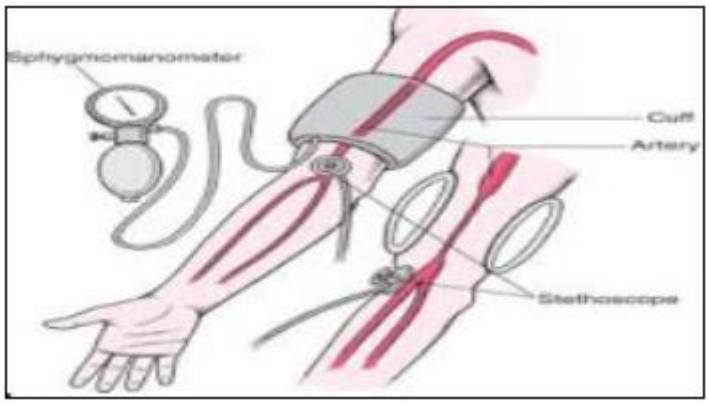
a. Dynes per square centimeters dynes/cm ^{2}

b. Newton per square meter N / m^2 (Pascal) or (Pa)

In medicine, the unit of pressure is measured by the height of a column of mercury (Hg).

Measurement of body pressure is a very common phenomenon in our lives.

e.g. the doctor measures our blood pressure as a part of a physical examination.



- Pressure under a column of liquid:

P = ρ g h

ρ = density of the liquid

For mercury ρ=13.6 g/cm^3, for water ρ=1 g/cm^3

g = acceleration due to gravity

h = height of the column

The unit is N/m^2

$P = \rho g h$

$\rho = (kg/m^3)$

$g = 9.8\ m/\ sec^2$

h = in (m)

Example: What height of water will produce the same pressure as 120 mm Hg?

For mercury:

$P\ (120\ mm\ Hg) = \rho g h$

$= (13.6\ g/cm^3)*(980\ cm/sec^2)*(12\ cm)$

$=1.6*105\ dyne/cm^2$

For water:

$1.6*105\ dyne/cm^2 = (1.0\ g/cm^3)*(980\ cm/sec^2)*(h\ cm\ H_2O)$

$\therefore h = 163\ cm\ H_2O$

Devices used to measure pressure

1- U - shape tube manometer

used to measure either a (+ve) or (-ve) pressure.

2- Tonometer

used to measure the eye pressure (+ve pressure only)

3- Cystometer

used to measure the urinary bladder.

4-Sphygmomanometer

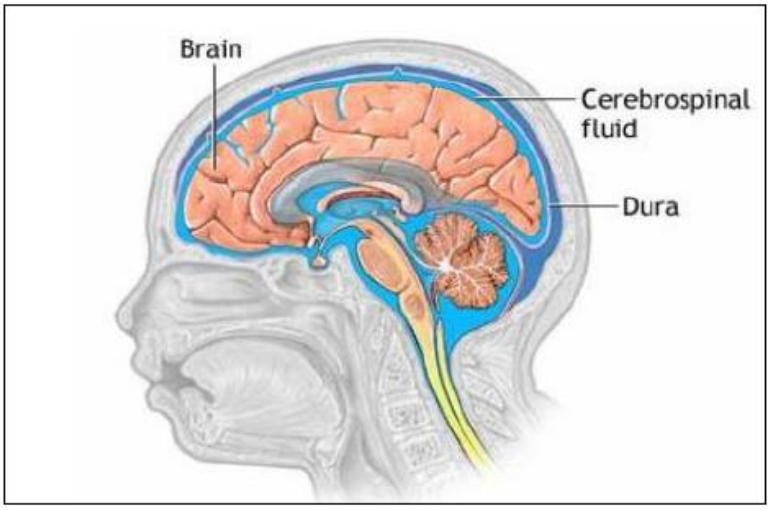
used to measure the blood pressure (+ve pre.)

The pressure inside the skull:

The brain contains about (150cm^3) of cerebrospinal fluid "CSF" in a series of interconnected openings called "Ventricles"

CSF is generated inside the brain and flows throw the ventricles into the spinal column and eventually into the circulatory system.

One of the ventricles of the aqueduct is especially narrow. If at birth this opening is blocked for any reason, the CSF is trapped inside the skull and increases the internal pressure, the increased pressure causes the skull to enlarge, this condition is called "Hydrocephalus".



Detection of hydrocephalus:

It is not convenient to measure the CSF pressure directly. The method to detect hydrocephalus is to measure the circumference of the skull just above the ears.

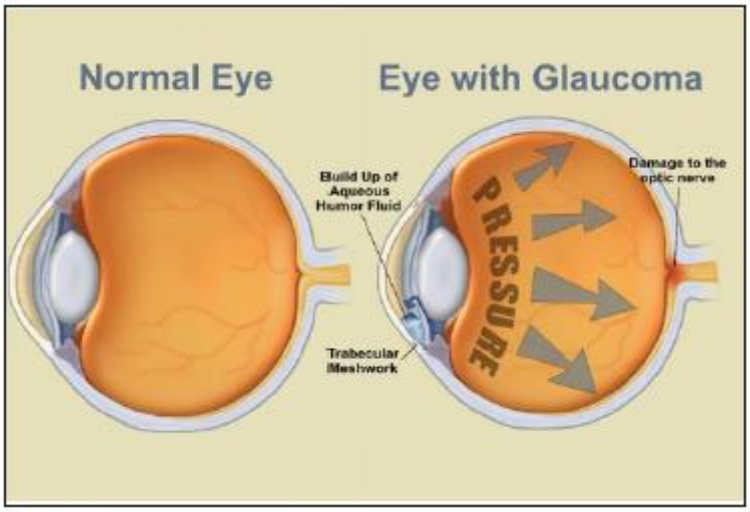
1- Normal value for the circumference of the skull of an infant is (32 to 37 cm), and a larger value may indicate hydrocephalus.

2- Transillumination: Make use of the light-scattering properties of the rather clear CSF inside the skull.

Eye Pressure:

The clear fluids in the eyeball (aqueous and vitreous humour) are under pressures that maintain the eyeball in a fixed size and shape. (That transmit the light to the retina).

The dimensions of the eye are critical to good vision. A change of only 0.1mm in its diameter has a significant effect on the clarity of vision.



If a partial blockage of this drain system occurs, the pressure increases and the increased pressure can restrict the blood supply to the retina and thus affect the vision.

This condition called Glaucoma, produces tunnel vision in moderate cases and blindness in sever conditions.

Stomach:

The pressure in it is increased because of the stretching of the stomach walls. The pressure inside the stomach increase by:

1- The accumulation of food, then it causes the stomach wall to stretch and then the volume of the stomach increase.

2- Air swallowed during eating, air trapped in the stomach causes belching.

Pressure in the skeleton:

This is the highest pressure that can be found in the body, for example when all the weight of the body is on one leg, such as when walking, the pressure in the knee joint may be more than 10 atmospheres.

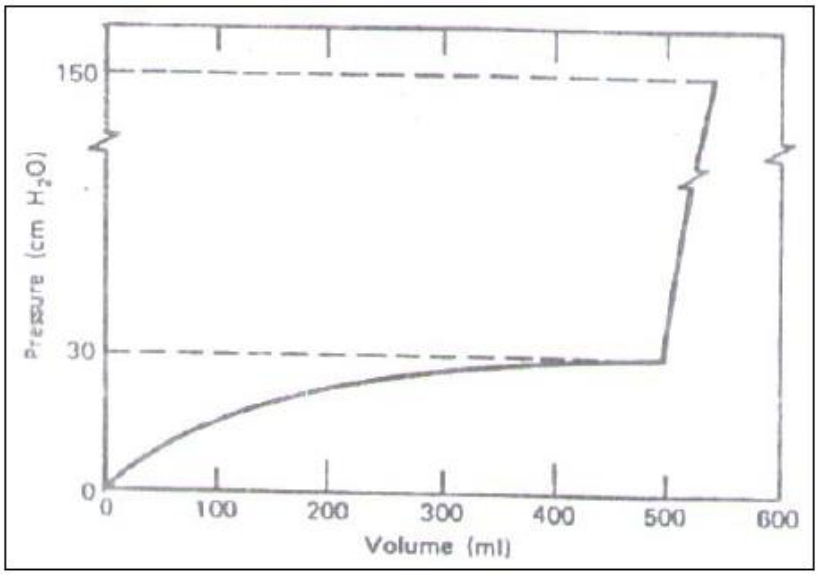
$P=F/A$ ……. (1)

The surface area of a bone at the joint is greater than its area either above or below the joint. The larger area at the joint distributes the force, thus reducing the pressure. According to equation 1.

Pressure in the urinary bladder:

One of the most noticeable internal pressure is the pressure in the bladder this pressure is due to the accumulation of the urine.

For adults, the typical maximum volume in the bladder before voiding is 500ml.



The bladder pressure increases during:

1- Coughing
2- Straining
3- Sitting up
4- During pregnancy (During pregnancy, the weight of the fetus over the bladder increase the bladder pressure and causes frequent urination).

There are two methods to measure urinary bladder pressure:

1- " In "direct" cystometry, which can be done by inserting a needle (connected to a pressure sensor), through the walls of the abdomen directly into the bladder.

2- Pressure in the bladder can be measured by passing a catheter with a pressure sensor into the bladder through the urinary passage (urethra). The catheter is connected from the other side to the pressure transducer.