PRESSURE

Pressure is defined as the force per unit area in a gas or liquid. For a solid the quantity force per unit area is referred to as stress. In the metric system pressure is measured in dynes per square centimeter (Dy/cm^2) or Newton per square meter (N/m^2) or Pascal (Pa).

If the unit is Dy/cm^2

$P = \rho\, g\, h$ ρ = density of liquid (g/cm^3)

$g = 980(cm/sec^2)$ acceleration of gravity

h= in (cm) the height of liquid

Or the unit is N/m^2

$P = \rho\, g\, h$ $\rho = (kg/m^3)$

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

$h = In\ (m)$

Example

Find the pressure of 10 m of water in Dy/cm^2 and N/m^2?

$10 \times 100 = 1000\ cm$ $1m=100cm$

$\therefore\ P = \rho\, g\, h = 1\times980\times1000=980000=9.8\times10^5\ Dy/cm^2$

$P = \rho\, g\, h = 1000 \times 9.8 \times10 =9.8\times10^4\ N/m^2$

The most common method of indicating pressure in medicine is by the height of a column of mercury (Hg). For example, a peak (systolic) blood pressure reading of 120 mmHg indicates that a column of mercury of this height has a pressure at its base equal to the patient's systolic blood pressure.

Example

Calculate the systolic pressure in Dy/cm^2 and N/m^2?

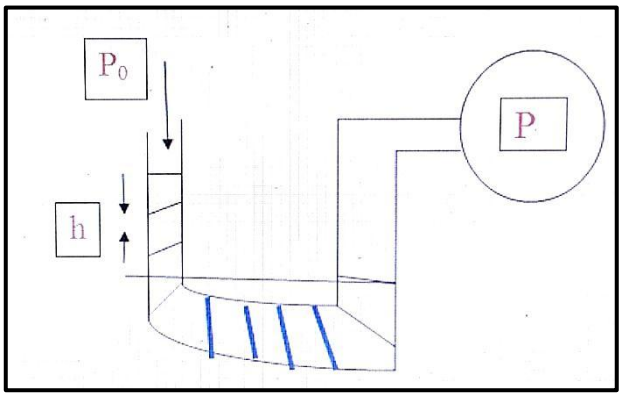
In systolic pressure =120 mmHg=12 cmHg

= 0.12 m Hg

$\therefore$ $P = \rho_{Hg}\, g\, h_{Hg} = 13.6 \times 980 \times 12 = 159936 = 1.6 \times 10^5$ Dy/cm^2

$P = \rho_{Hg}\, g\, h_{Hg} = 13600 \times 9.8 \times 0.12 = 1.6 \times 10^4$ N/m^2

The Instrument that measures pressure is called a manometer. A common type of manometer is U- shaped tube containing a fluid that is connected to the pressure to be measured Fig.



P_0= atmospheric pressure, h= height of liquid, P=the pressure of container.

The most common clinical instrument used in measuring pressure is the sphygmomanometer , which measures blood pressure. three types of pressure gauges are used in sphygmomanometers:

1- Mercury manometers: the pressure is indicated by the height of a column of mercury inside a glass tube.

2-Aneroid: the pressure changes the shape of a sealed flexible container, which causes a needle to move on a dial.

3- digital.

Pressure scales:

Pressure can be represented in three different scales:

1-Gauge pressure : it is the pressure measured relative to local atmospheric pressure.

Gauge pressure $=\rho\ g\ h=1000\ x\ 9.8x10=10^5\ N/m^2 \quad = 1\ atm$

2-Absolute pressure: it is the pressure measured relative to absolute zero.

Absolute pressure =atmospheric pressure+gauge pressure =1+ 1= 2 atm

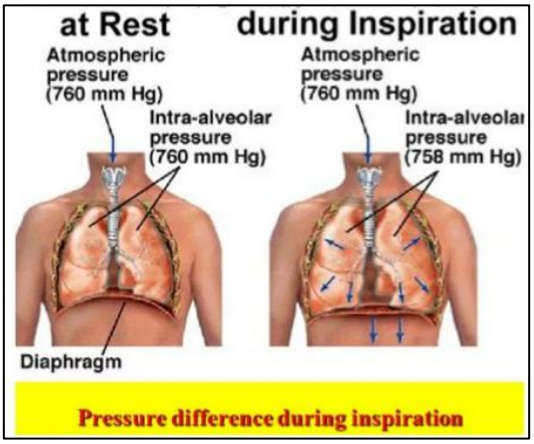
Or In $N/m^2 \ =10^5 + 10^5 = 2x\ 10^5 \ N/m^2$

Atmospheric pressure = $\rho_{Hg}\ g\ h_{Hg} \quad =13600x\ 9.8\ x0.76=10^5\ N/m^2$

3-Vacuum pressure: it is pressure less than atmospheric pressure measured relative to the local atmospheric pressure.

Negative pressure:

Any pressure lower than atmospheric pressure. For example , when we breathe in (inspire)the pressure in the lungs must be somewhat lower than atmospheric pressure.

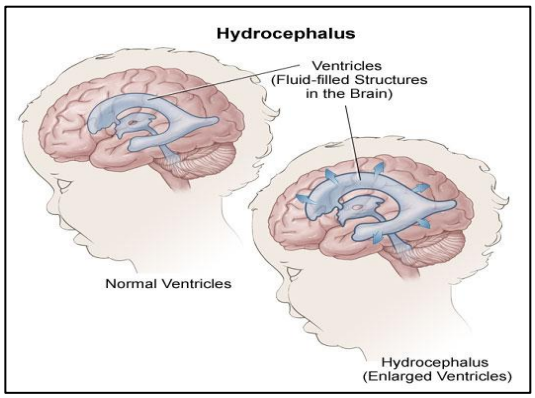


Pressure inside the skull :

The brain contains approximately 150 cm^3 of cerebrospinal fluid (CSF) (water head) in a series of interconnected openings called ventricles.

If at birth this opening is blocked for any reason, the CSF is trapped inside the skull and increased the internal pressure, this increase pressure cause the skull to enlarge. This serious condition, called hydrocephalus.

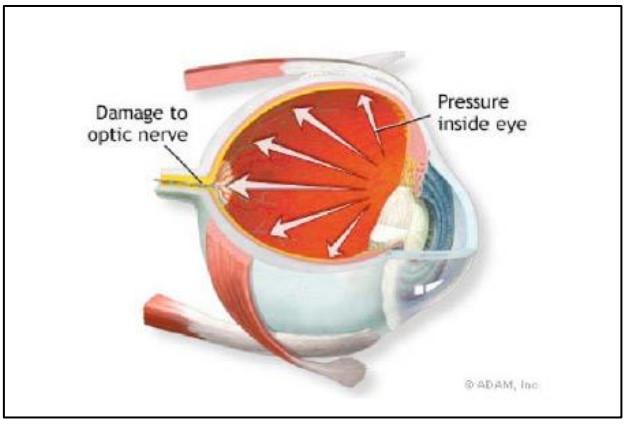
Measurement of hydrocephalus



1- Crude method: - by measuring the circumference of the skull just above the ears .Normal values of newborn infants are from 32-37 cm, and larger than this may indicate hydrocephalus.
2- qualitative method (transillumination):-
   In this method light – scattering properties is used.

Eye pressure:

The clear fluids in the eye ball that transmit the light to retina (the light sensitive part of the eye), are under pressure and maintain the eye ball in fixed size and shape. If a partial blockage of the drain system occurs, the pressure increase then restrict the blood the blood supply to the retina then affect the vision. This condition, called glaucoma. The pressure in normal eyes ranges from (12 –23) mmHg.



Measuring the eye pressure :

1- By (feel)the physician estimate the pressure inside the eye by (feel) as they pressed on the eye with their fingertips

2-Tonometers . ch.15

Pressure in skeleton:

The highest pressures in the body are found in the weight bearing bone (joints).

The pressure in the knee joint may be more Than 10 atm. $P=F/A$---------- *(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 the equation 1.

Bone has adapted in another way to reduce pressure the finger bones are flat rather than cylindrical and the force is spread over a large surface this reducing tissues over the bones according to $P=F/A$.

Pressure in the urinary bladder :

The internal pressure in the bladder is due to the accumulation of the urine. The figure below shows the typical pressure - volume curve for the bladder, which stretches as the volume increase.

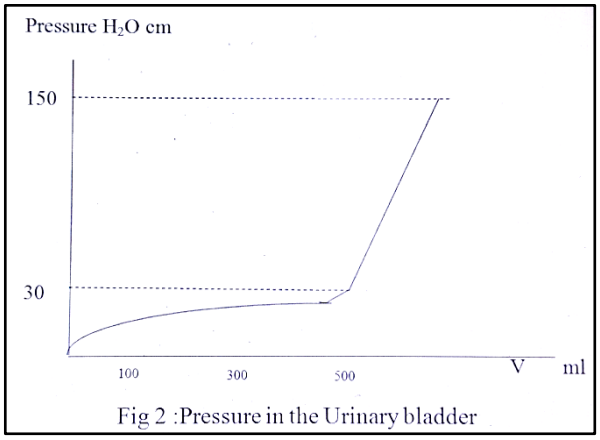


Fig 2 :Pressure in the Urinary bladder

Volume in the bladder before voiding is (500) ml. at some pressure (~30 cm H_2O).The resulting sizable muscular contraction in the bladder wall produces a momentary pressure of up to 150 cmH_2O.

The pressure in the bladder can be measured:

1-By passing a catheter with a pressure sensor into the bladder through the urinary passage (urethra).

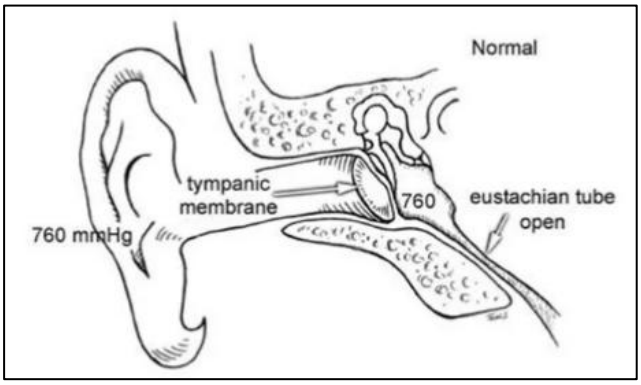
2-By a needle inserted through the wall of the abdomen directly into the bladder.

The bladder pressure increases during coughing, straining, sitting up, also during pregnancy the weight of the fetus over the bladder increase the bladder pressure and causes frequent urination.

The pressure in ear

The middle ear is one of the air cavities that exist within the body. For comfort the pressure in the middle ear should be equal to the pressure on the outside of the eardrum.

$P_{middle\ ear} = P_{outside\ the\ eardrum}$, this equalization is produced by air flowing through the Eustachian tube , which is usually closed except during swallowing , chewing ,and yawning.



*When diving many people have difficulty obtaining pressure equalization and feel pressure on their ears.

*(120mmHg) across the eardrum, which can occur in about 1.7 m of water, can cause the damage to the eardrum.

The pressure in the lung:-

$P_{in\ the\ lung\ at\ any\ depth} > P_{in\ the\ lung\ at\ sea\ level}$

This means that the air in the lung is denser under water and that the partial pressures of all the air components are proportionately higher .

1- Partial pressure of O_2 is (0.8 atm) and absolute air pressure is (4 atm) at depth of (30 m).The higher partial pressure of O_2 causes more O_2

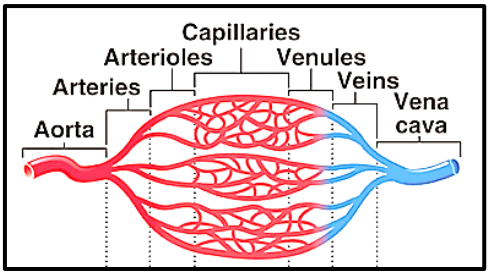
molecules to be transformed into the blood , and oxygen poisoning results if the partial pressure of O_2 gets high .

2- Breathing air at a depth of (30m) is also dangerous because it may result in excess N_2 in the blood and tissues ,there is a possibility of having :

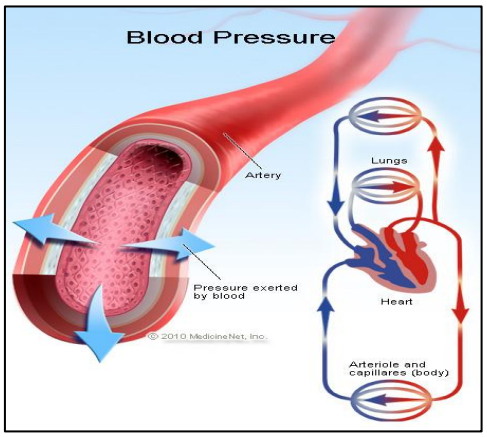
- Nitrogen narcosis (intoxication effect).
- The bends or decompression sickness (a scant problem).

*O_2 is attached to red blood cells , while N_2 is dissolved in the blood and tissues .

Blood Pressure



- Blood flows from the heart through arteries, which branch and narrow into arterioles. The capillaries then join and widen to become venules, which then return blood back to the heart through the great veins. the network of capillaries supplying organs and tissues.



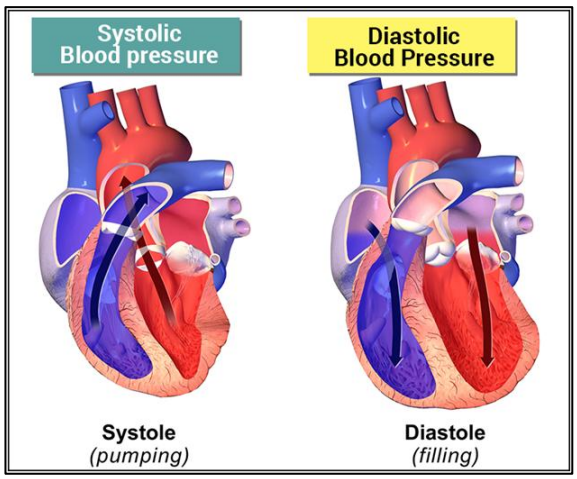
- The blood pressure is the force exerted by the blood against the vessel wall, it is produced primarily by the contraction of the heart muscle.

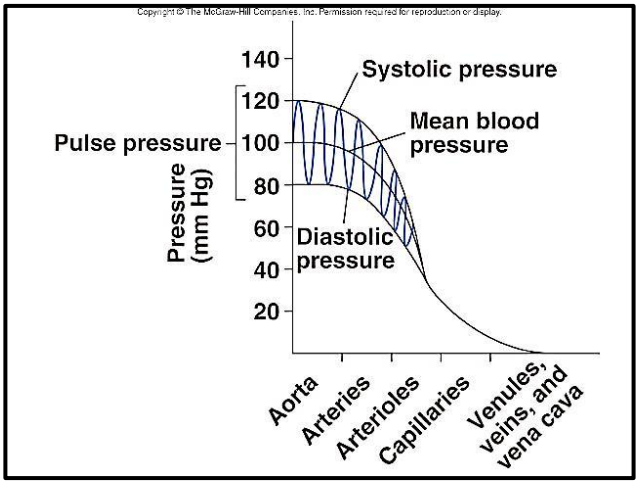
- The blood pressure measurement is recorded by two numbers:

The first (systolic pressure): it is maximum pressure exerted in the arteries during systole of ventricle. Average 120mmHg.

The second (diastolic pressure): it is minimum pressure within the arteries during the diastolic of ventricle. Average 80mmHg.

Difference between systolic and diastolic pressures, Increases when stroke volume increases or vascular compliance decreases, pulse pressure can be used to take a pulse to determine heart rate.





- A blood pressure cuff is used to measure the pressure. Elevation of blood pressure is called "hypertension".