

Pressure

Introduction:

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)
 $g=980(\text{cm/sec}^2)$ acceleration of gravity
 h = in (cm) the height of liquid

Or the unit is N/m^2

$$P = \rho g h$$

ρ = (kg/m^3)
 $g= 9.8 \text{ m/ sec}^2$
 h = In (m)

Example -1-

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

$$10 \times 100 = 1000 \text{ cm} \quad 1\text{m}=100\text{cm}$$

$$\therefore P = \rho g h = 1 \times 980 \times 1000 = 980000 = 9.8 \times 10^5 \text{ Dy/cm}^2$$

$$P = \rho g h = 1000 \times 9.8 \times 10 = 9.8 \times 10^4 \text{ N/m}^2$$

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 patients systolic blood pressure .

Example -2-

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

$$\begin{aligned} \text{In systolic pressure} &= 120 \text{ mmHg} = 12 \text{ cmHg} \\ &= 0.12 \text{ m Hg} \end{aligned}$$

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

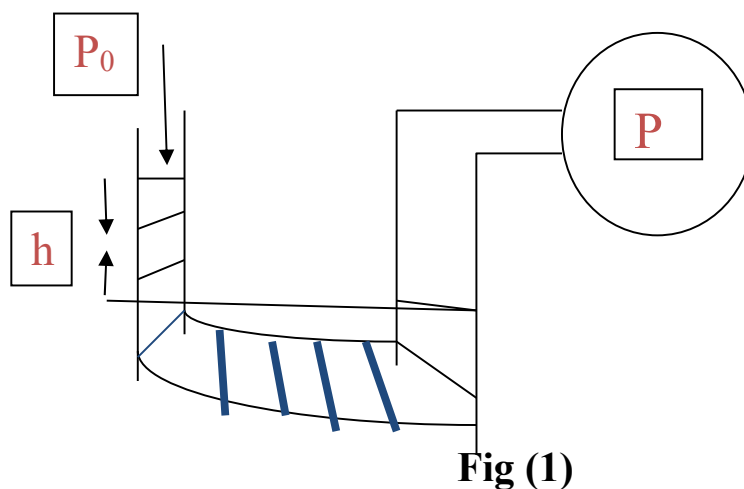
$$P = \rho_{Hg} g h_{Hg} = 13600 \times 9.8 \times 0.12 = 1.6 \times 10^4 \text{ N/m}^2$$

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 (1).

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. Two types of pressure gauges are used in sphygmomanometers.

1- Mercury manometers.

2- Aneroid.

Recently another type used (digital).

Gauge pressure :is defined as the excess pressure over atmospheric pressure.

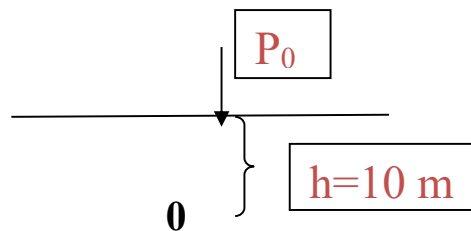
$$\begin{aligned} \text{Gauge pressure} &= \rho g h \\ &= 1000 \times 9.8 \times 10 \\ &= 10^5 \text{ N/m}^2 = 1 \text{ atm} \end{aligned}$$

$$\begin{aligned} \text{Absolute pressure} &= \text{atmospheric pressure} + \text{gauge pressure} \\ &= 1 + 1 = 2 \text{ atm} \end{aligned}$$

Or In N/m^2

$$=10^5 + 10^5 = 2 \times 10^5 \text{ N/m}^2$$

$$\text{Atmospheric pressure} = \rho_{\text{Hg}} g h_{\text{Hg}} = 13600 \times 9.8 \times 0.76 \\ = 10^5 \text{ N/m}^2$$



Negative pressure:

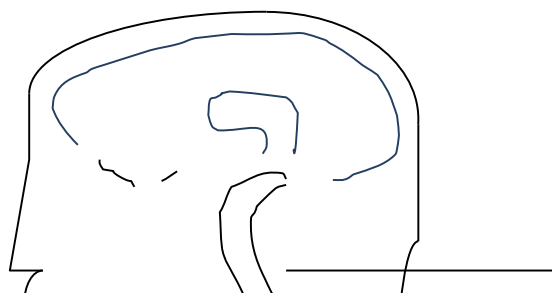
Any pressure lower than atmospheric pressure. For example, when we breathe in (inspire) the pressure in the lungs must be somewhat lower than atmospheric pressure or the air would not flow in.

Pressure inside the skull :

The brain contains approximately 150 cm^3 of cerebrospinal fluid (CSF) 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 serious condition, called hydrocephalus.

Measurement of hydrocephalus

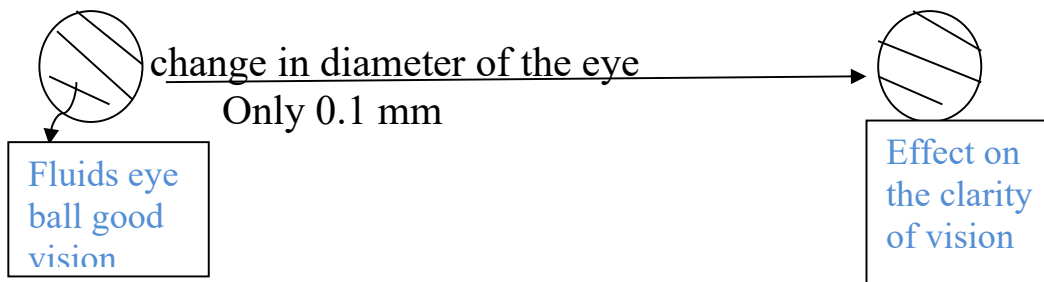
- 1- Crude method: - In this method the circumference of the skull just above the ears. Normal values of newborn infants are from 32-37 cm, and larger than this may indicate hydrocephalus.
- 2- qualitative method (transillumination):-
In this method light – scattering properties is used.



Spinal Cord

Eye pressure: The clear fluids in the eye ball (aqueous and vitreous humors) 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.

Normal eye



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.

Glaucoma : a. Moderate -----tunnel vision
 b . Sever-----blindness

The pressure in normal eyes ranges from (12 –23) mm.Hg

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 on the gripping side 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.

Pressure H₂O cm

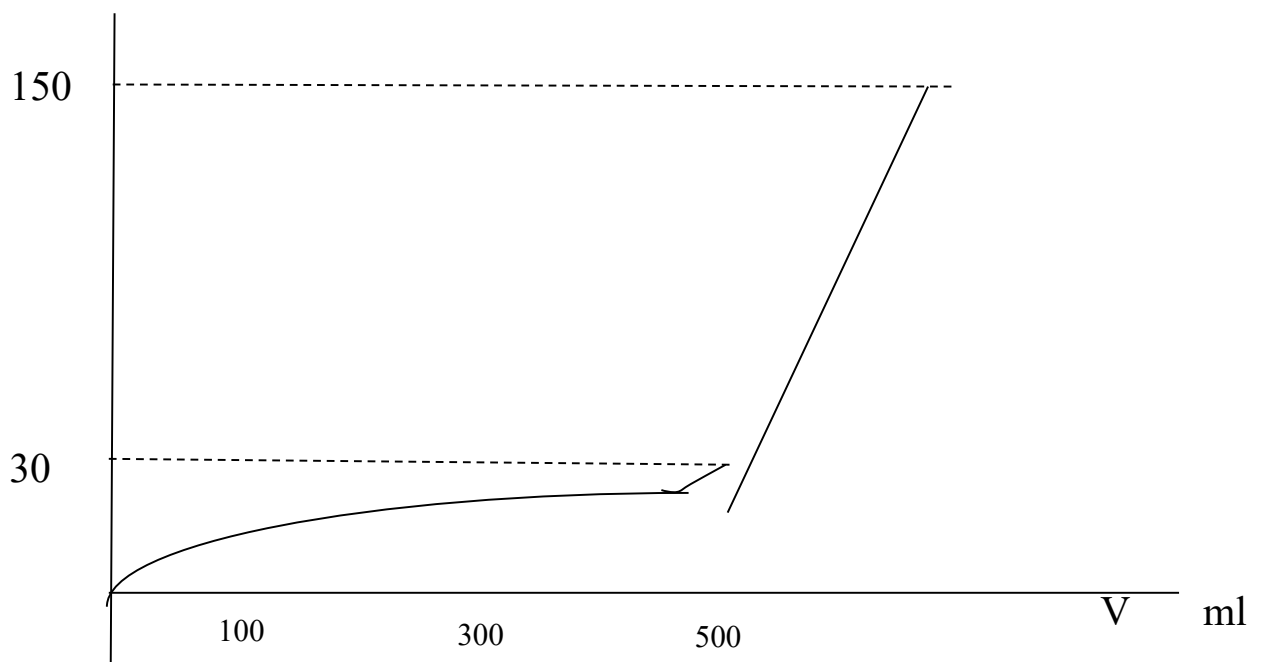


Fig 2 :Pressure in the Urinary bladder
or adults, the typical max. Volume in the bladder before voiding is (500) ml. at some pressure (~30 cm H₂O) the micturition reflex occurs .

The resulting sizable muscular contraction in the bladder wall produces a momentary pressure of up to 150 cmH₂O.

The pressure in the bladder can be measured:

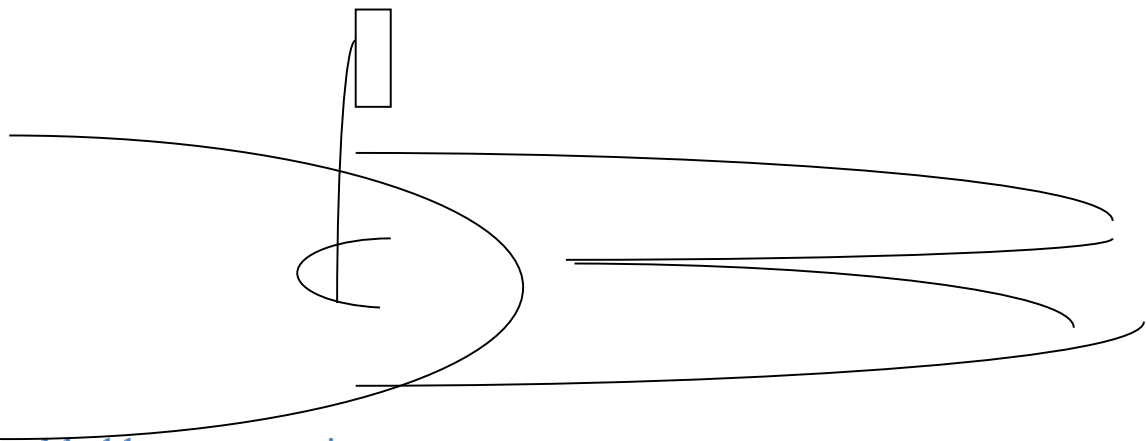
*By passing a catheter with a pressure sensor into the bladder through the urinary passage (urethra).

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

This technique gives information about the function of the exit valves that can not be obtained with the catheter technique.

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.

Normal voiding pressure is fairly low (20-40)cmH₂O but for Men who suffer from prostate obstruction of the urinary passage it may be over 100cmH₂O.



The bladder pressure increase.....

Boyle s law:

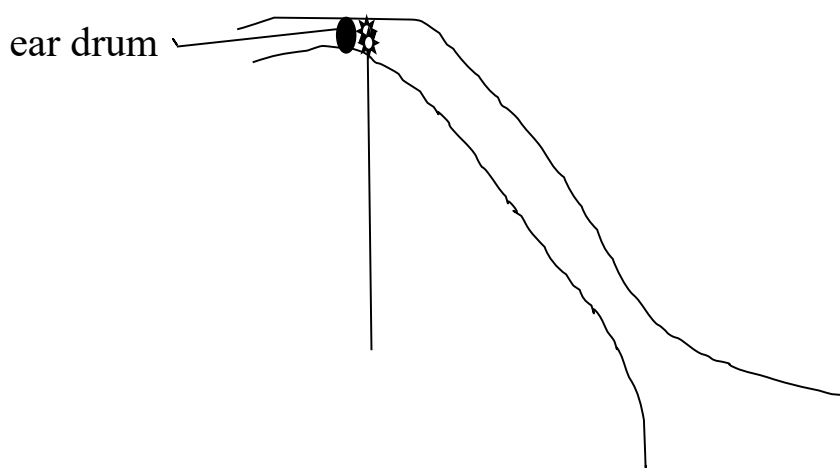
For a fixed quantity of gas at a fixed temperature the product of the absolute and volume is constant.(PV=constant)

$$P_1 V_1 = P_2 V_2$$

That is ,if the absolute pressure is double, the volume is halved.

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.



Middle ear

Eustachian tube

Pressure effect while diving

$P_{\text{middle ear}} = P_{\text{outside the eardrum}}$, 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 (rupture) to the eardrum.

One method of equalization used by a diver is to raise the pressure in the mouth by holding the nose and trying to blow out.

The pressure in the lung:-

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

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- 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 .Partial pressure of O_2 is (0.8 atm) and absolute air pressure is (4 atm) at depth of (30 m).
- 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).
- *O₂ is attached to red blood cells , while N₂ is dissolved in the blood and tissues .

Hyperbaric Oxygen Therapy (HOT):-

The body normally lives in an atmosphere that is about one fifth O₂ and four – fifth N₂. In some medical situations it is beneficial to increase the proportion of O₂ in order to provide more O₂ to the tissue.

1- Gas gangrene :-

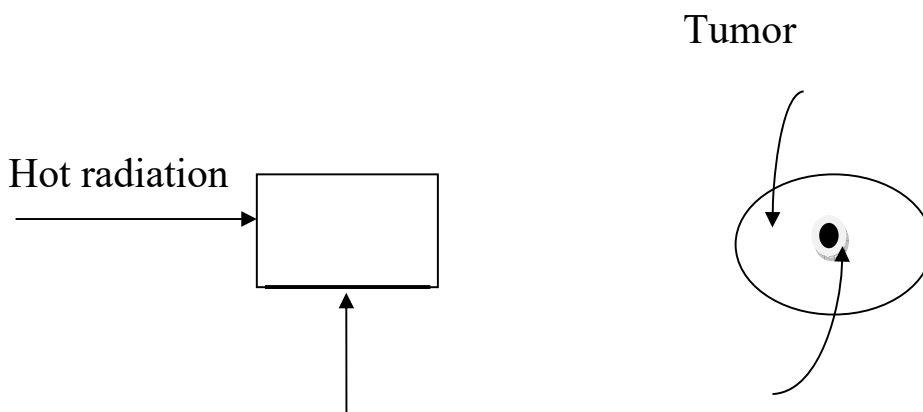
The bacillus causes gas gangrene then its treated with (HOT) . That is due to bacillus cannot survive in the presence of oxygen (O₂).

2- Carbon Monoxide poisoning :-

- The red blood cells cannot carry O₂ to the tissues because the carbon monoxide fasters to the hemoglobin at the places normally used by O₂.
- Normally the amount of O₂ dissolved in the blood is about 2% of that carried on the red blood cells.
- By using the (HOT) technique , the partial pressure of O₂ can be increased by a factor of 15, permitting enough O₂ to be dissolved to fill the body's need .

3- Treatment of cancer :-

(HOT) with radiation is given to the patient in transparent plastic tank. The theory was that more oxygen would make the poorly oxygenated radiation-resistant cell in the center of the tumor more susceptible to radiation damage .



Transparent plastic tank

center
(Poorly oxygenated)

Q: If the pressure of a man is 8 cm Hg, Does the man have prostate or not?

A/: $P_{Hg} = P_{Water}$

$$P_{Hg} = \rho g h_{water}$$

The (g) is canceled from both sides

$$13.6 \times 8 = 1 \times h_{water}$$

$H_{Water} = 108.8$ cm. so the man has prostate

Note:

- ▲ If $h_{water} = 100$the man has prostate
- ▲ If $h_{water} > 100$the man has prostate
- ▲ If $h_{water} < 100$the man is normal