Pressure

Pressure is defined as the force per unit area. The pressure P under a column of liquid can be calculated from the following low:

$$P = \rho g h$$

Where the: ρ is the density of the liquid

g is the acceleration due to the gravity   h is height of the column

Ex:- what height of water will be produced the same pressure as 120 mmHg.

- Solution: $P = \rho g h = 13.6 x 980 x 12$
- $= 1.6 x 10^5$ dy/cm^2
- For water $P = \rho g h$
- $1.6 x 10^5 = 1 x 980 x h$
- So $h = 163$ cm H_2o

Or $(\rho\, g\, h)_{Hg} = (\rho\, g\, h)_{H2o}$

$$\rho_{Hg}\, h_{Hg} = \rho_{H2o}\, h_{H2o}$$

$$h_{H2o} = (13.6x12)/1 = 163\ cmH_2o$$

Ex:- Calculate the atmospheric pressure in N/m^2

- Solution:- 1 atm =760 mmHg =76 cmHg
- The atmospheric pressure in N/m^2 is equal
- $P = \rho g h = 13600 kg/m^3 x 9.8 m/s^2 x 0.76 m$

$= 1.01x10^5 N/m^2$

Gauge Pressure

- The excess pressure over atmospheric pressure.

Negative Pressure

- Any pressure lower than atmospheric pressure. For example: The lung pressure during inspiration is a few centimeter of water negative ,a person drink through a straw the pressure in his mouth must be negative.
- There are numbers of places in the body where the pressure is lower than atmospheric pressure or negative .For example when we breath inspire the pressure in the lungs must be lower than the atmospheric pressure .

The most common clinical instrument used in the measuring pressure is the sphygmomanometer, which measure s blood pressure.

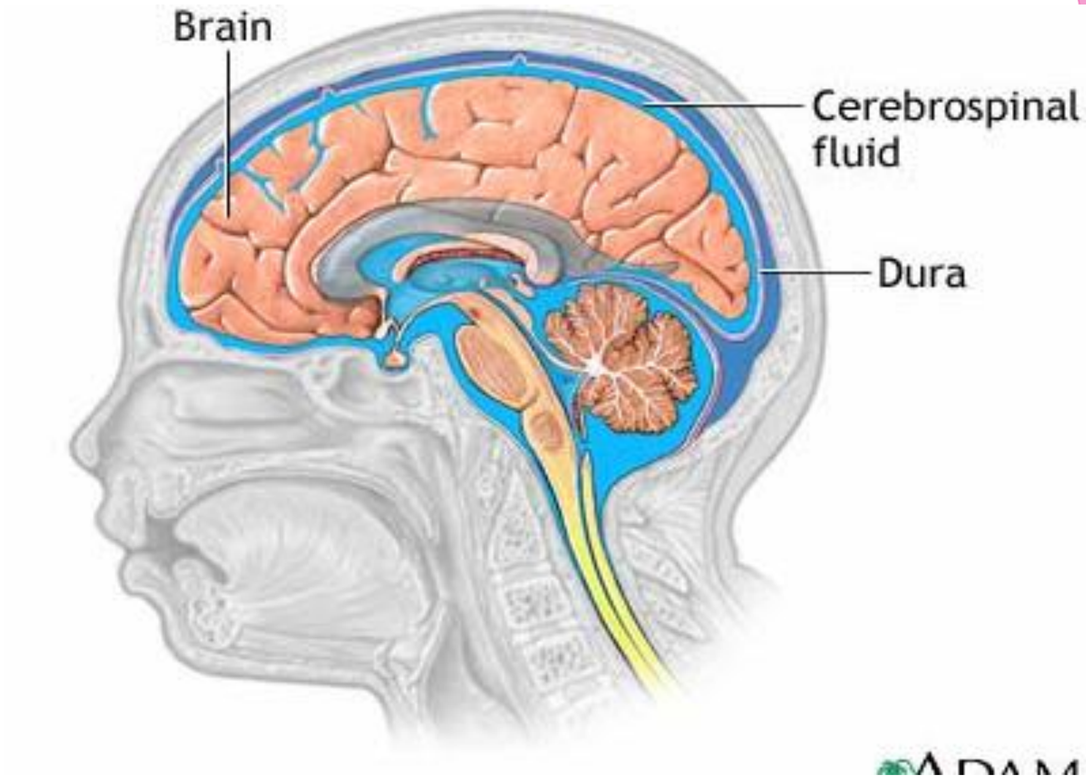
Typical pressure in the normal body

Different parts of the body	Typical pressure(mmHg)
Arterial blood pressure	
Max.(systole)	100 - 140
Min.(diastole)	60 - 90
Venous blood pressure	3 - 7
Middle ear pressure	less than 1
Eye pressure	20
CSF inside the brain	5 - 12

Measurement of pressure in the body
An instrument that measures pressure is called a manometer. The common clinical instrument used in measuring pressure is the sphygmomanometer .Two types of pressure gauges are used in sphygmomanometer, they are

Pressure inside the skull

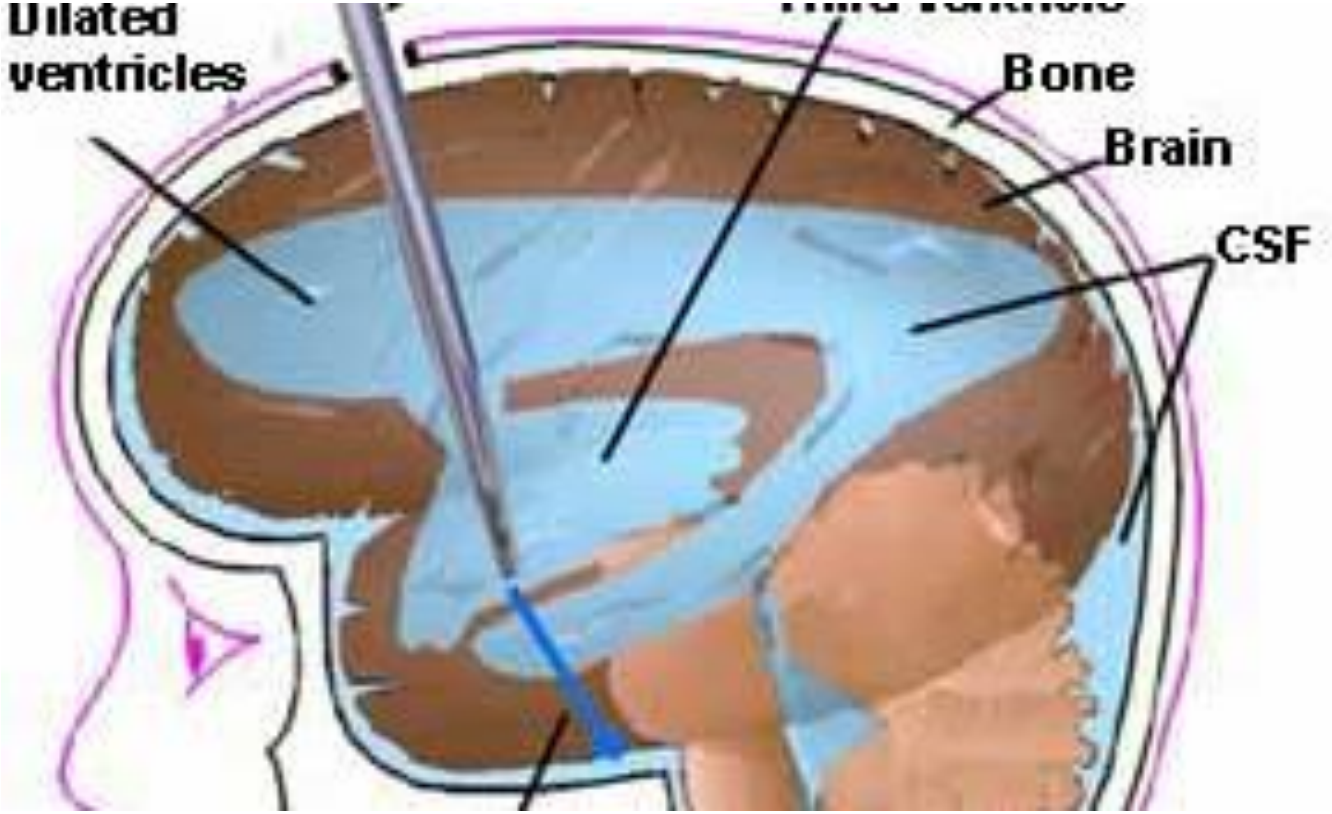
- The brain contains approximately 150cm3of cerebral spinal fluid (CSF) in a series of inter connected openings called ventricles



CSF (brain)----to ventricles-----to spinal column-----to circulatory system.

One of the ventricles, 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 serious condition is called hydrocephalous.



It can often be corrected by surgically installing a by _ pass drainage system for CSF.

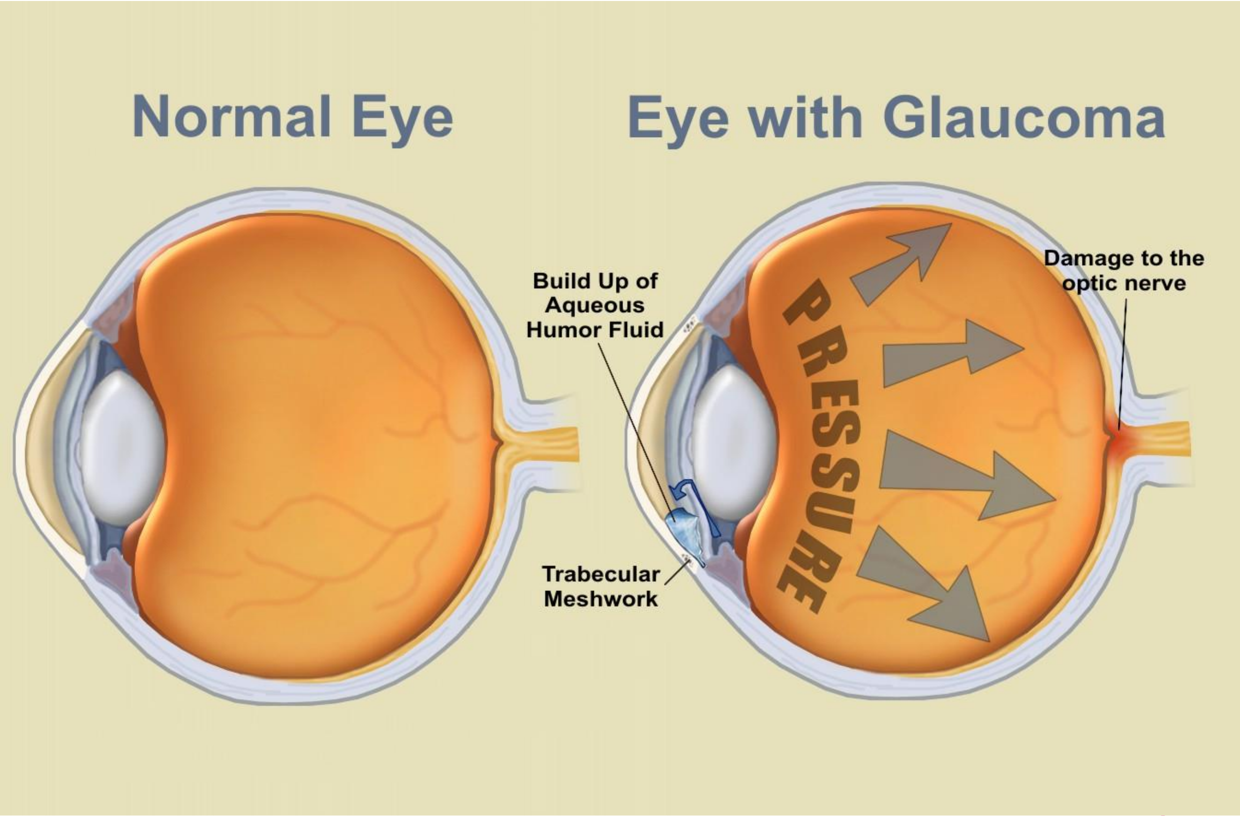
Measuring the CSF pressure

- It is not convenient to measure the SCF pressure directly. There are two methods:
- 1-Crude method: This method can measure the pressure inside the skull by measuring the circumference of the skull just above the ears. Normal values for newborn infants are from (32-37) cm, and a

larger value may indicate hydrocephalus.

2-Transillumination: is a qualitative method of detection. Make use of the light -scattering properties of the rather clear CSF inside the skull.

Eye pressure



The clear fluids in the eye ball (aqueous and vitreous humors) that transmit the light to the retina (the light sensitive part of the eye), are under pressure and maintain the eye ball in a fixed size and shape

-If a partial blockage of the drain system occurs, the pressure increase of restrict the blood supply to the retina then affect the vision. This condition, called glaucoma.

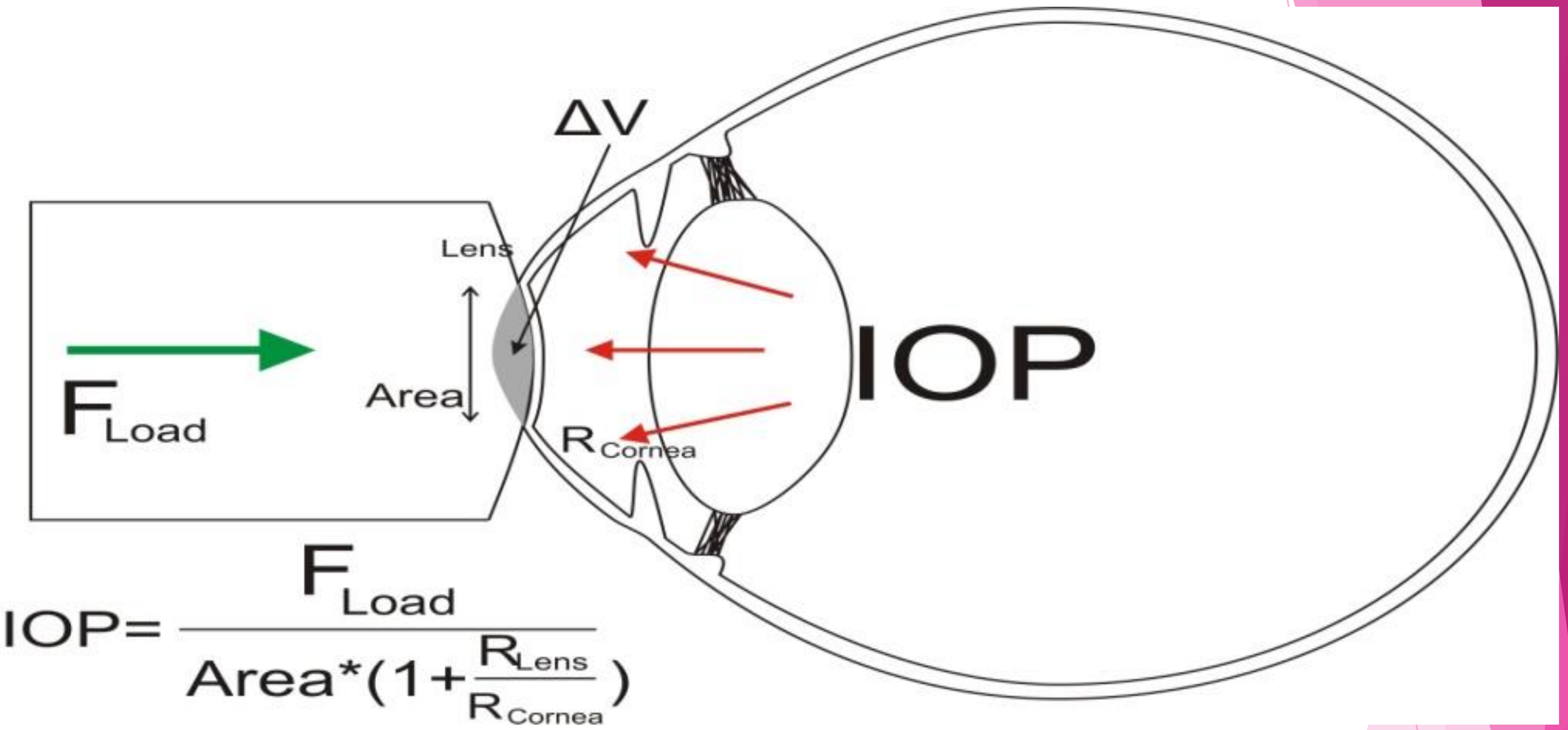
Glaucoma: 1- moderate---------tunnel vision

2- severe--------------blindness

-The pressure in normal eyes ranges from (12 – 23) mmHg.

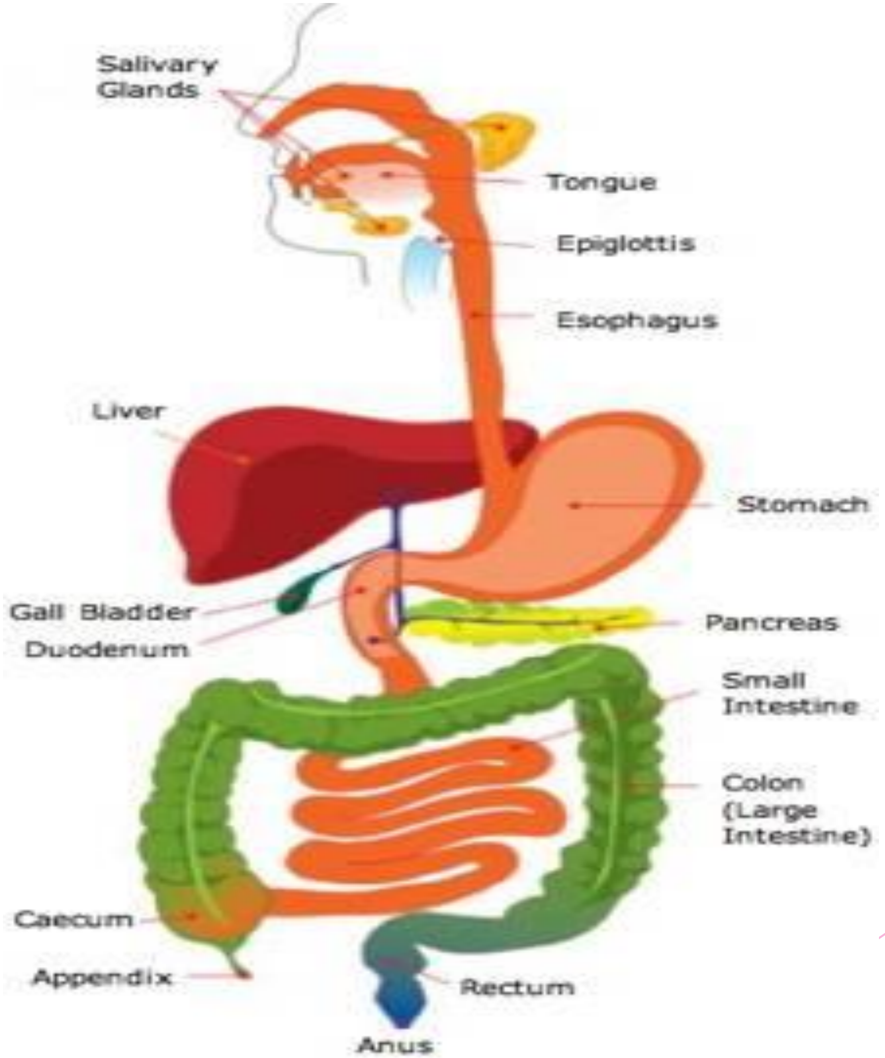
Measuring the eye pressure

- 1-By feel the physicians estimate the pressure inside the eye by feel as they pressed on the eye with their fingertips.
- 2-By the tonometer



An instrument is used to measure intraocular pressure(IOP).

Pressure in the Digestive System



-Opening through the body
-Over 6 m
-Closed in the lower end and has several restrictions
-Valves and sphincters permit unidirectional flow of food.

Pressure in the gastrointestinal (GI) system
-Greater than atmospheric pressure in most parts

-Esophagus pressure is usually less than atmospheric pressure

-Pressure in the stomach

A-Eating increases the pressure in the stomach slowly due to increased volume

B-Air swallowed during eating increases the pressure in the stomach → burping or belching

-Pressure in the gut

A-Bacteria action generates gas (flatus) →increase gut pressure

B- Belts, girdles, or swimming → affect gut pressure

Pylorus : valve

-Prevents the flow of food back into the stomach from the small intestine

-blockage in the small or large intestine → high pressure between the blockage and the pylorus → blockage of blood flow to critical organs → death

-Treatment

A-Intubation: a hollow tube though the nose, stomach, and pylorus

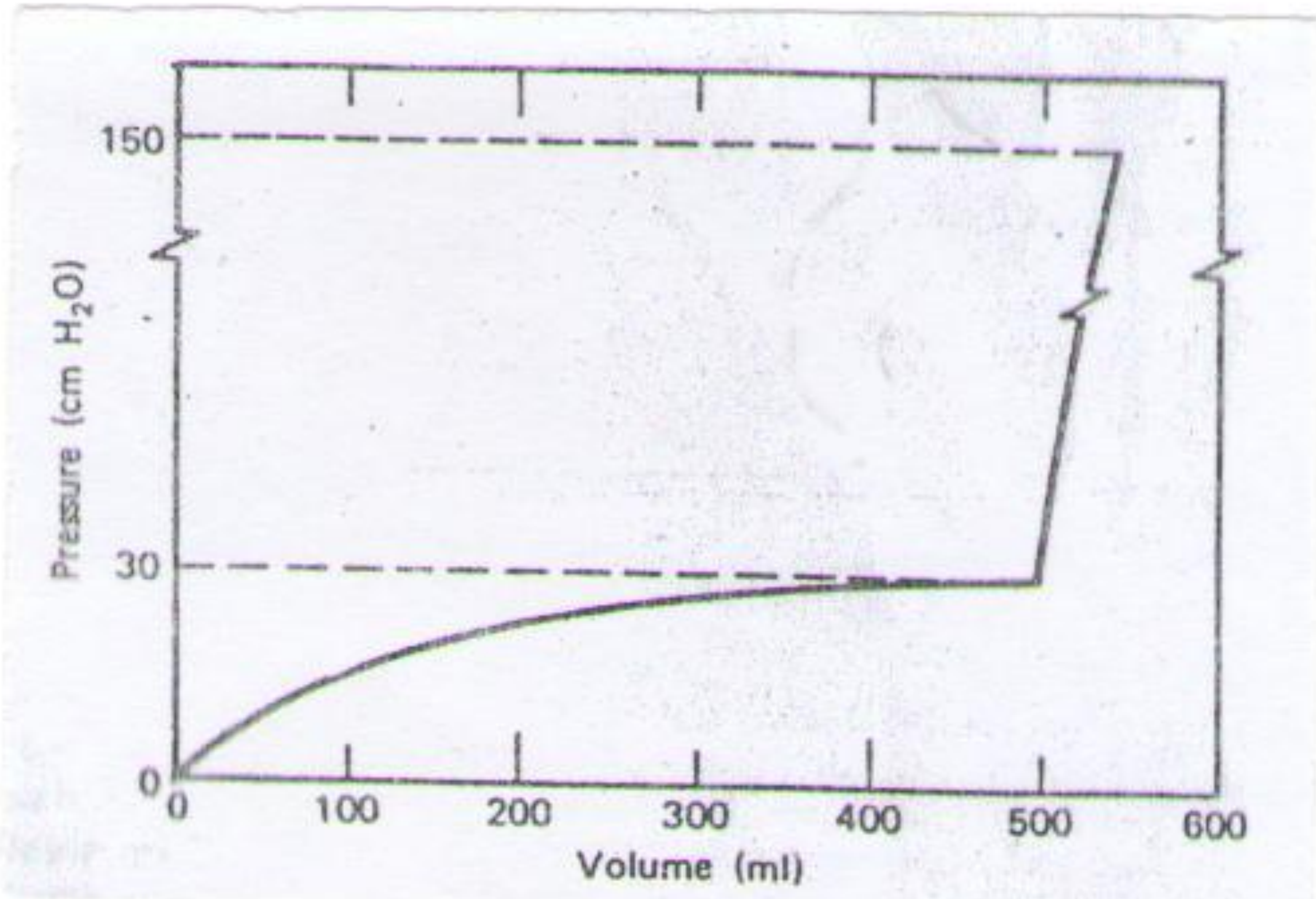
B-Surgery in a pressure-controlled operating room

Pressure in the 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 equation (1).
- -Bone has adapted in another way to reduce pressure, the finger bones are flat rather force is spread over a larger surface, this reducing the tissues over the bones according to P=F/A.

Pressure in the urinary bladder

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


150
30
0
Pressure (cm H_2O)
0
100
200
300
400
500
600
Volume (ml)

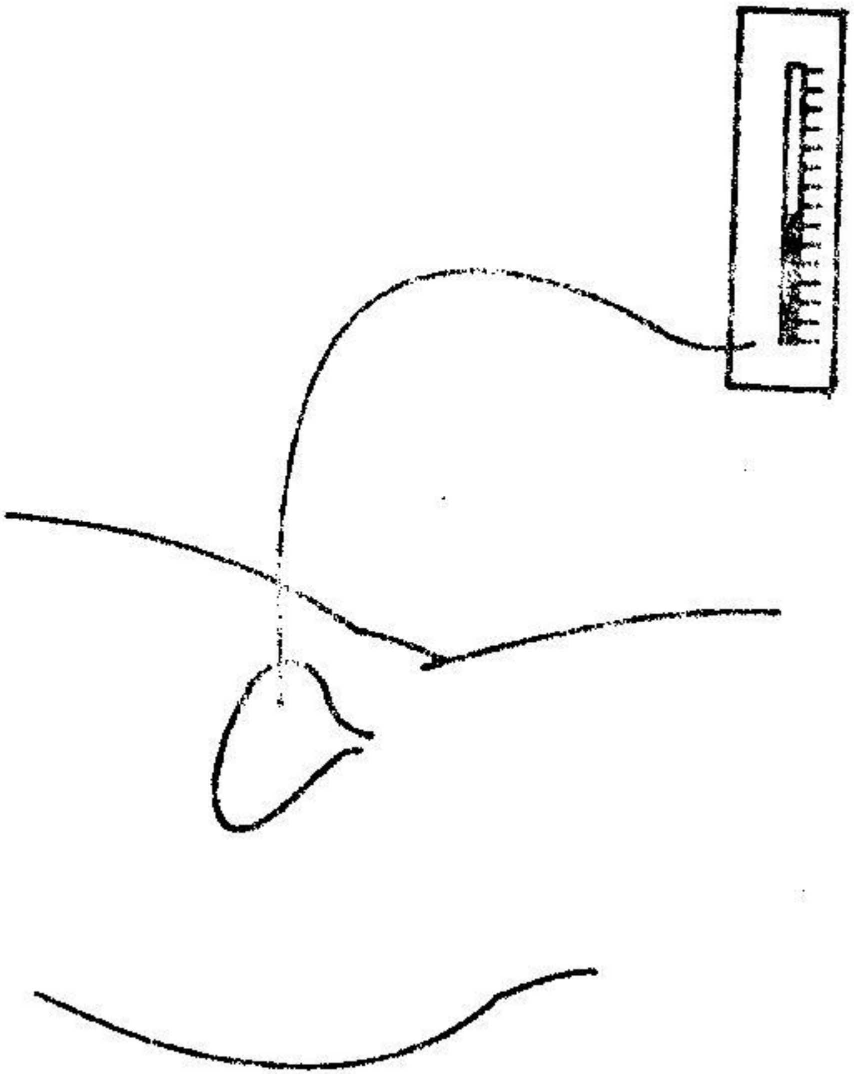
-For adult, the typical max. Volume in the bladder before voiding is 500ml. At some pressure nearly 30cmH2o the micturition reflex occurs.

-The resulting sizable muscular contraction in the bladder wall produces a momentary pressure of up to 150cmH20.

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



-The bladder pressure increases during coughing , straining , sitting up , also during pregnancy the weight of 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 100 cmH2o

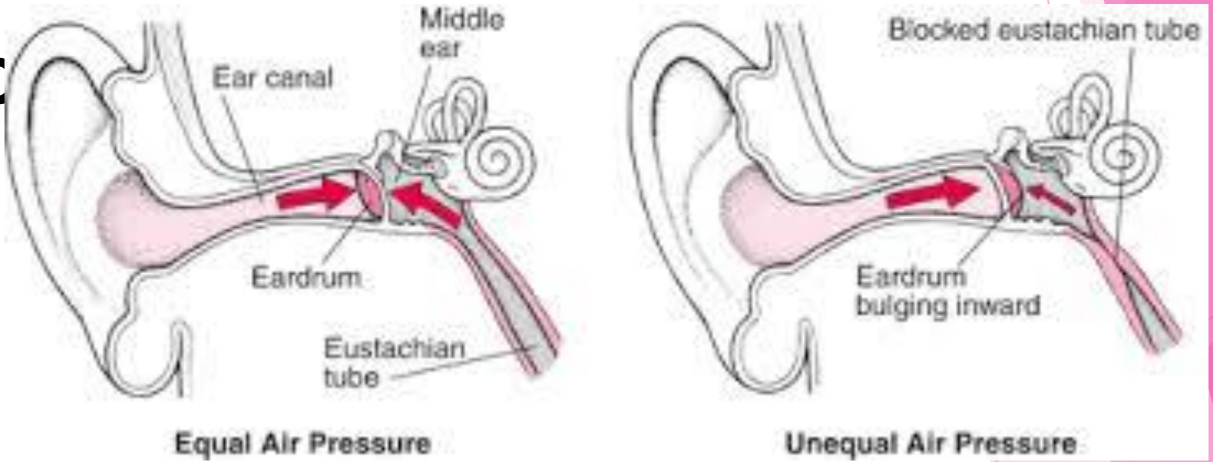
Pressure effects while diving

- The body is composed primarily of solids and liquids, which are nearly incompressible. Pressure changes; do not greatly affect most of it . However, there are gas cavities in the body where sudden pressure changes can produce profound effects.

Boyles law

- For a fixed quantity of gas a fixed temperature the product of the absolute and volume is constant.
- PV= constant
- = constant$P_1V_1=P_2V_2$
- That is, if the absolute pressure is doubled, 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 to the pressure on the outside c



$$P_{\text{middle ear}} = P_{\text{outside eardrum}}$$

This equalized is produced by air flowing through the Eustachian tube, which is usually closed except during swallowing, chewing, and yawning

-When diving many people has difficulty obtaining pressure equalization and feels pressure on their ears.

-(120mmHg) across the eardrum , which can occur in about 1.7 m of water ,can cause damage (rupture) to the eardrum . One method of equalization used by diver is to raise the pressure in the mouth by holding the nose and trying to blow

The pressure in the lung

- Pressure in the lung at any depth greater than the pressure in the lung at sea level. This means that the air in the lung is denser under water and that the partial pressure 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 the O_2 gets high. Partial pressure of O_2 is 0.8 atm and absolute air pressure is 4 atm at depth of 30m.

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:

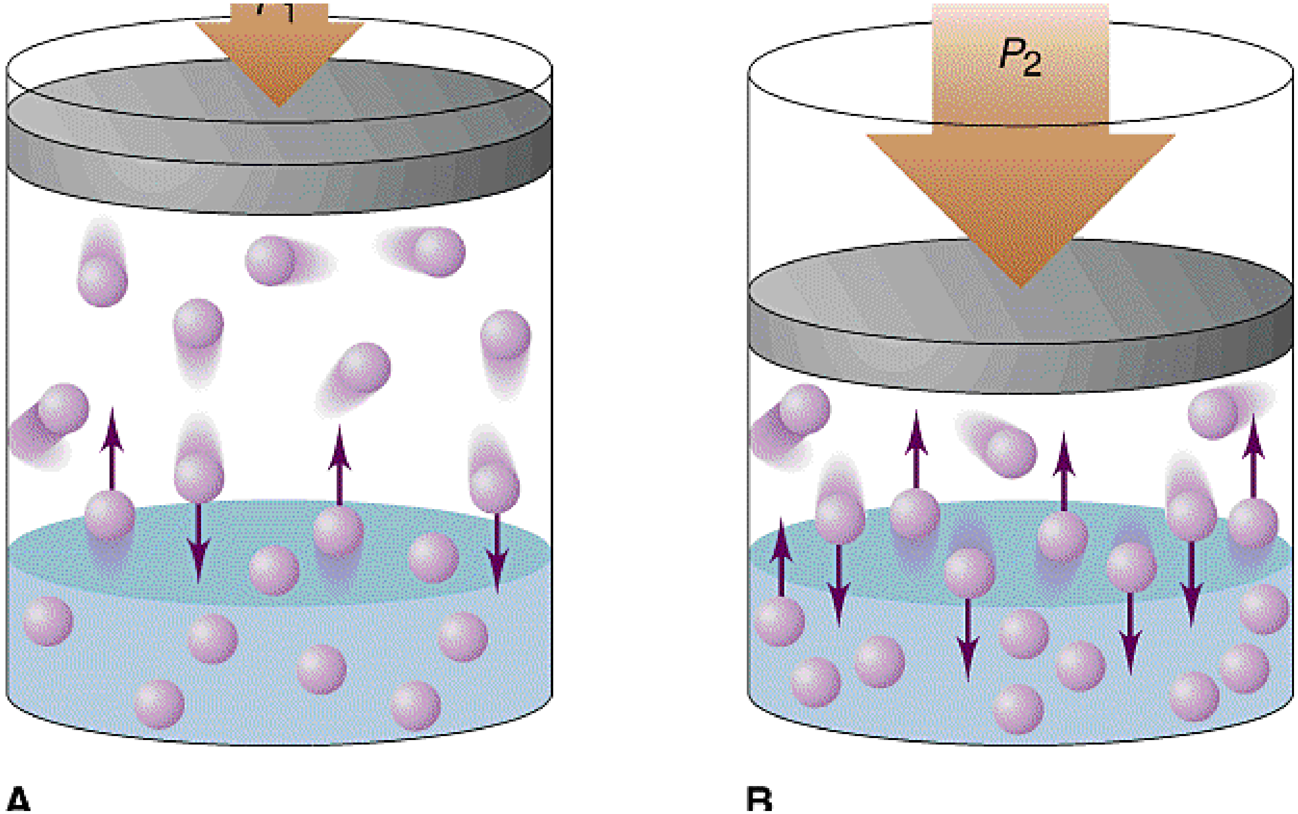
-Nitrogen narcosis (intoxication effect)

-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.

Henrys law



The amount of gas that will dissolve in a liquid is proportional to the partial pressure of the gas in contact with the liquid.

Hyperbaric oxygen therapy (HOT)

- The body normally lives in an atmosphere that is about one fifth O_2 and four-fifth N_2. In some medical situations it is beneficial to increase the proportion of O_2 in order to provide more O_2 to the tissue.

1-Gas gangrene:

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

2-Carbon monoxide poisoning:

-The red blood cells cannot carry O_2 to the tissues because the carbon monoxide fasters to the hemoglobin at the places normally used by O_2.

-Normally the amount of O_2 dissolved in the blood is about 2% of that carried on the red blood cells.

-By using the (HOT) technique, the partial pressure of O_2 can be increased by a factor of 15 , permitting enough O_2 to be dissolved to fill the body's needs

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.