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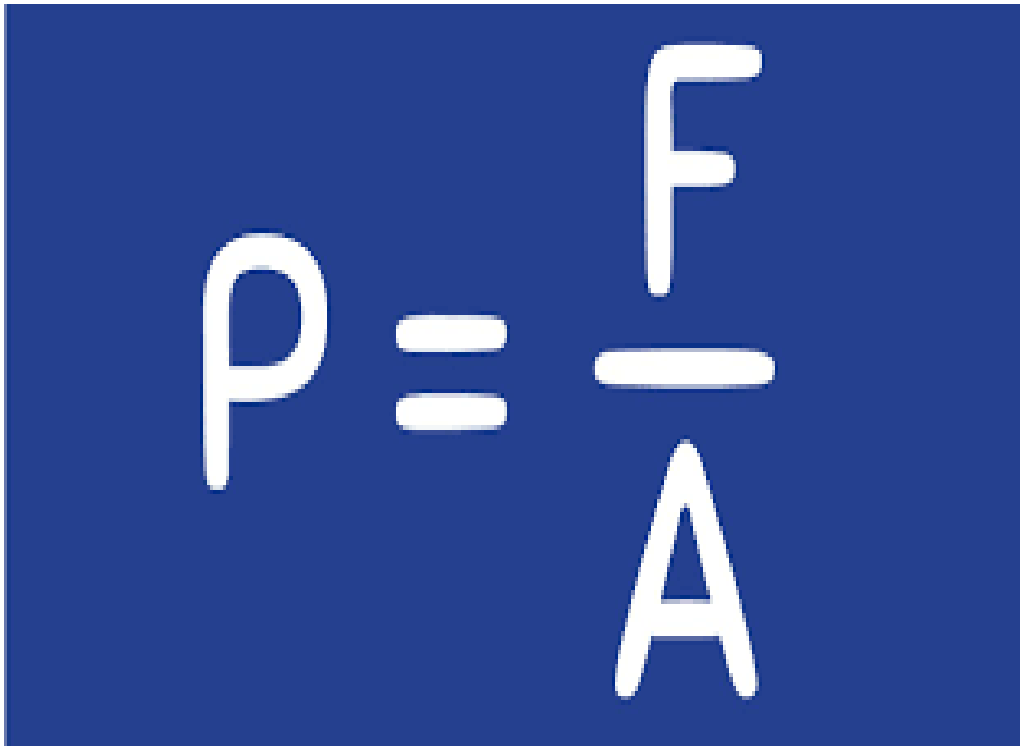
Pressure



Pressure:

It is the force per unit area in a gas or liquid. (For solid the term pressure is replaced by "stress").

Units:

In metric system pressure is measured in units

a. Dynes per square centimeters
b. Newton per square meter (**Pascal**) or (**Pa**)

Note:

none of the above units is in common in medicine.

The used unit is the height of a column of mercury (**Hg**)

The peak systolic pressure = 120mm Hg = a pressure of a liquid mercury of this height on its base. ***While the atmospheric pressure = 760mm Hg***

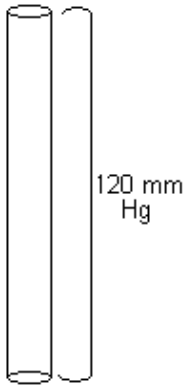


Table:

some of the common units used to measure Pressure

	Atmospheres	**N/m^2**	**cm H_2O**	**mmHg**
1 atmosphere	1	$1.01*10^5$	1033	760
1 N/m^2	$0.987*10^{-5}$	1	0.0102	0.0075
1 cm H_2O	$9.68*10^{-4}$	98.1	1	0.735
1 mm Hg	0.00132	133	1.36	1

Pressure (p) under column

P=ρgh

ρ : the density of liquid — for mercury $\rho = 13.6\ g/cm^2$; for water $\rho = 1\ g/cm^2$

g : the acceleration due to gravity

h : the height of the column

Question:

Calculate the length of water column that can produce the same pressure of a column of mercury of (1mm) length. **(Answer =13.6 mm)**

Example:

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

$P(120mmHg) = \rho gh = (13.6\ g / cm^2) * (980\ cm?sec^2) * (12\ cm) = 1.6*10^5\ dyne/cm^2$

For water

$1.6*10^5\ (dyne/cm^2) = (1.0\ g/cm^3)*(980\ cm/sec^2)*(h\ cm\ H_2O)$

$\therefore h = 163\ cm\ H_2O.$

Manometer:

This is a U-shaped tube containing a fluid that is connected to the pressure to be measured,
The levels in the arms change until the different in the levels
(h) is equal to the pressure.

* ***this type of manometer can measure both (positive) and (negative) pressure.***
*** The fluid used can be**:
1. Mercury for high pressure measurements.

2. Water or other low density fluid for low pressures.

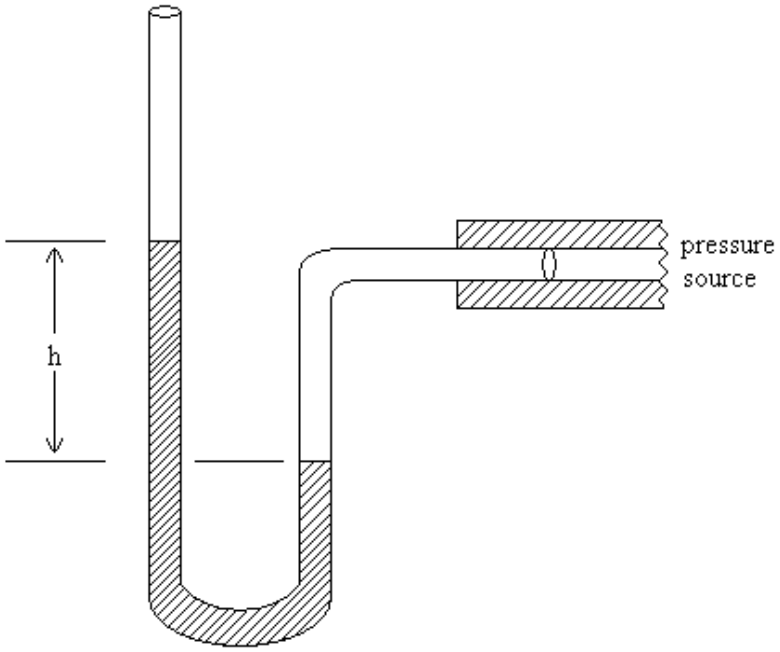


Figure. A U tube manometer for measuring pressure P.P can be expressed as the height of the fluid.

Sphygmomanometer:

is the clinical instrument used for measuring the blood pressure.

It can be provided by one of two types of gauges.
Mercury gauge: the pressure is indicated by the height of mercury inside a glass tube.

Aneroid type: the pressure changes the shape of a sealed flexible container, which cause a needle to move on a dial.

Pressure inside the skull:

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

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

* ***If at birth the narrow opening of the ventricle (aqueduct) is blocked then the CSF***

rapped inside the skull and hence increases the internal pressure .the increased pressure causes the skull to enlarge (A case named hydrocephalus).

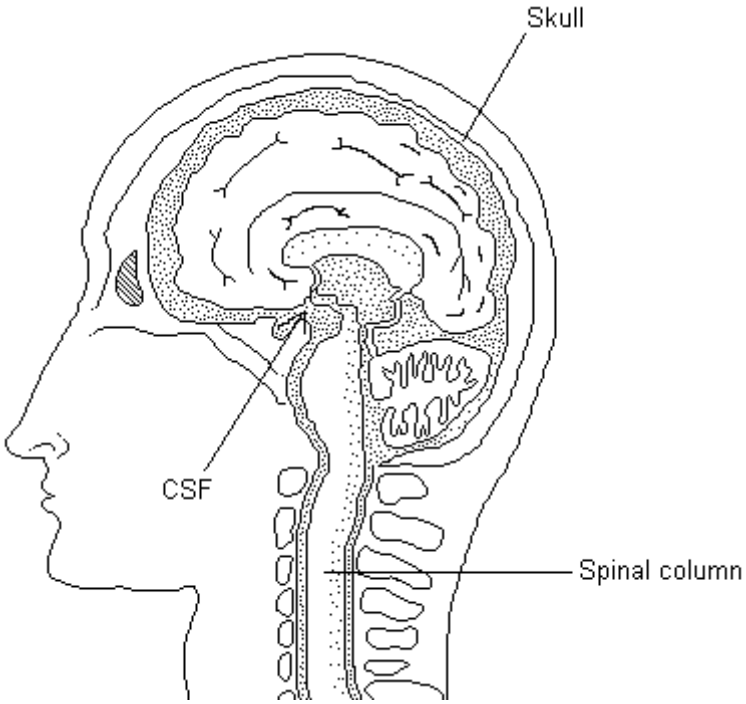


Figure. A cross-section pf the brain showing the location of the cerebrospinal fluid (shaded area) and the aqueduct (arrow).

*** There are two methods to detect hydrocephalus :**

1. By measuring the circumference of the skull just above the ears.

2. Transillumination, making use of light-scattering properties of the clear CSF inside the skull.

Eye Pressure: The clear fluids in the eyeball (the aqueous and vitreous humors) that transmit light to the retina are under pressure

* This pressure maintain the eyeball in a fixed size & shape. →A change of only 0.1mm in the eye diameter has a significant effect on the clarity of vision.

**** The pressure in normal eyes range from 12 to 23mm Hg.***

***** The eye continuously produces aqueous humors and a drain system allows escaping.

If the pressure increased due to a partial blockage then the blood supply to the retina will be restricted and thus affecting vision (glaucoma) which produce tunnel vision in moderate cases and blindness in severe cases.

Ton meters:

These are instruments used for measuring the amount of indentation produced by a certain force.

Pressure in the digestive system:

The digestive system is an opening through the body with about 6 meter length from the mouth to anus.

It has several values and sphincters (circular muscles) which open for the passage of food, drink, and their by-products, in a unidirectional flow.

Esophagus:

The pressure is less than the atmospheric because it is coupled to the pressure between the lungs and chest wall (intra-thoracic pressure).

Stomach:

The pressure is higher than the atmospheric pressure because of the stretching of the stomach walls and due to air swallowed during eating.

Gut:

gas flatus generated by the bacterial action increases the pressure, and hence it is higher the atmospheric.

**** Occasionally a blockage forms in the small or large intestine and a pressure build up between the blockage and the pylorus. If this pressure becomes great enough to restrict blood flow to critical organs, it can cause death. And can be solved by:***

1. Intubation: -
passing of a hollow tube through nose, stomach, and pylorus.

2. Surgery: -
chosen when the intubations don't work.

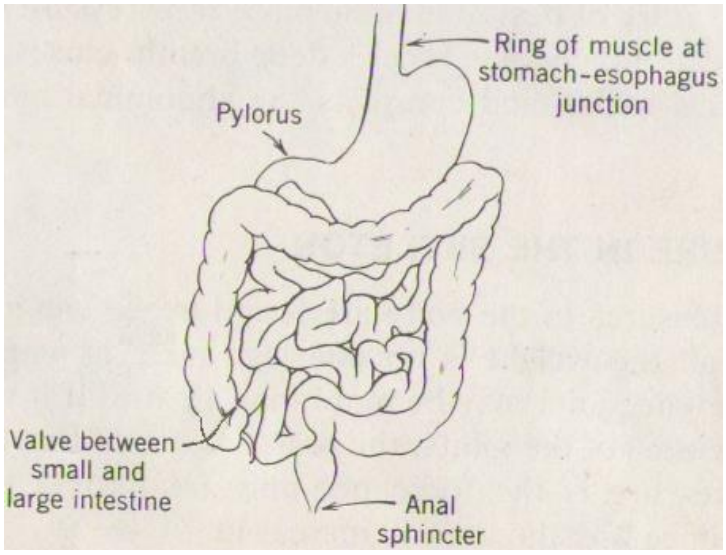


Figure. The valves and sphincters of the digestive tract.

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***!!

**** 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***.

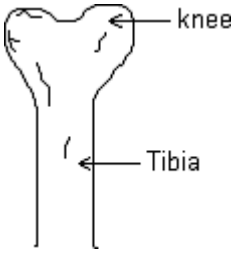


Figure. The surface area of a bone at the joint is greater than its area either above or below the joint.

* **Healthy bone joints are better lubricated than the best man-made bearings. The human joints system is such that; the higher pressure → the better lubrication.**

Fingers: The finger bones are flat rather than cylindrical on the gripping side, and the force is spread over a large surface, thus reduces pressure in the tissues over the bones.

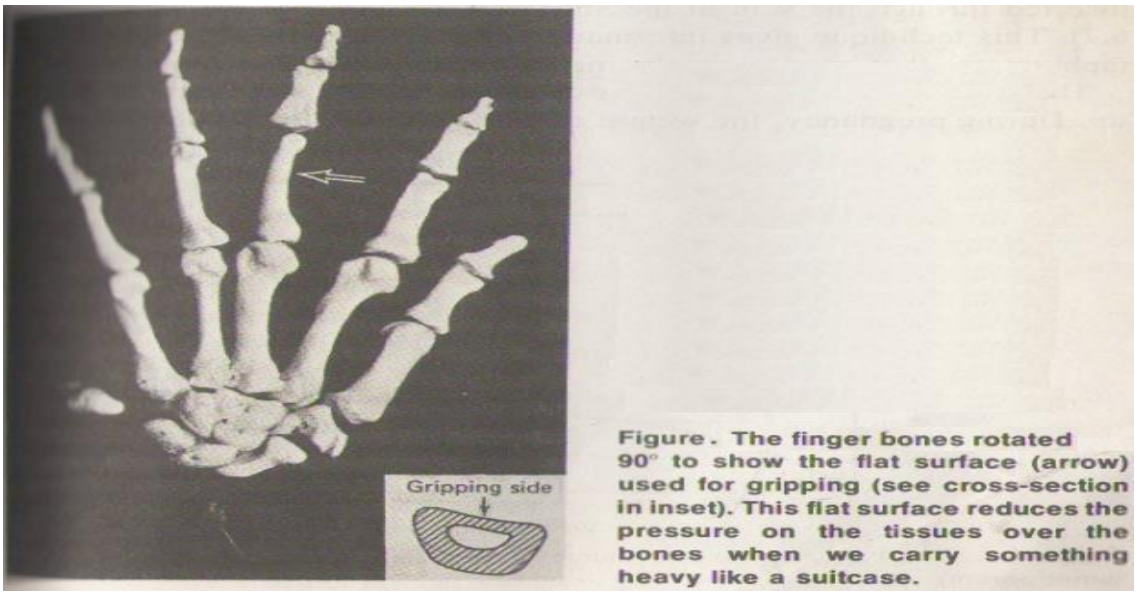


Figure. The finger bones rotated 90° to show the flat surface (arrow) used for gripping (see cross-section in inset). This flat surface reduces the pressure on the tissues over the bones when we carry something heavy like a suitcase.

Pressure in the urinary bladder:-

The figure below shows the typical pressure-volume curve for the bladder

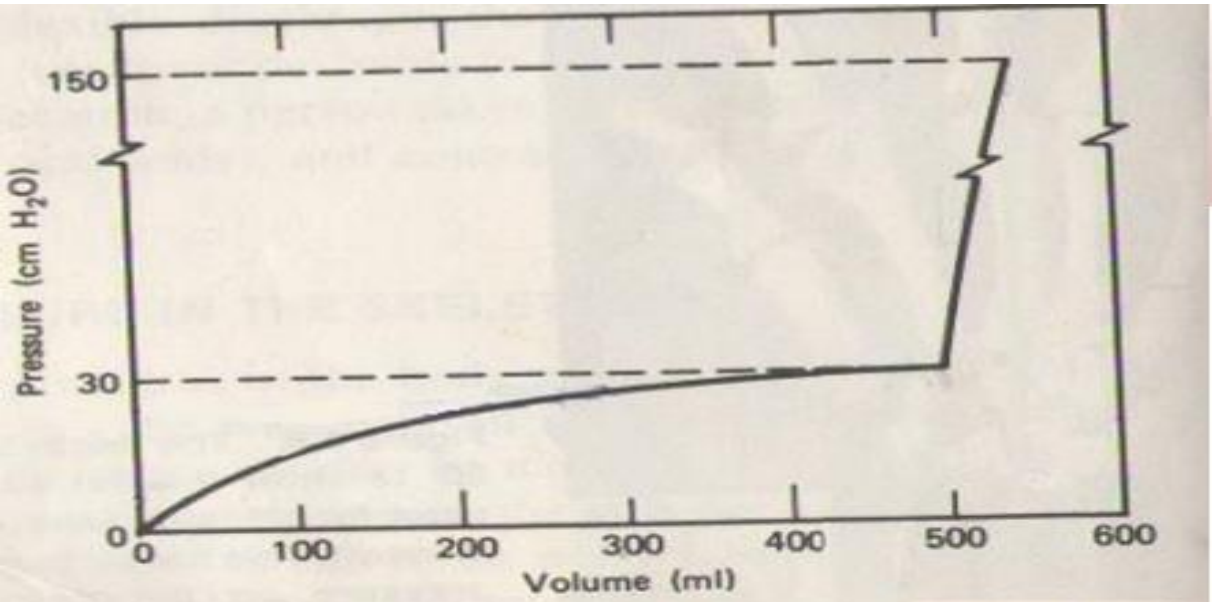


Figure. The typical pressure-volume relationship in the urinary bladder (cystometrogram).

*An increase in the **radius** of the bladder **R** will cause:
*An increase in the volume $\mathbf{R^3}$
*An increase in the pressure $\mathbf{R^2}$

The above relationship accounts for the relatively low slope in the major portion of the figure.

→ **For adults**, the typical maximum volume of the bladder before voiding is 500 ml and at some pressure ***(~ 30 cm H_2O***) the micturation reflex occurs

→ The resulting sizable muscular contraction in the bladder wall produce a momentary pressure up to (***150cm H_2O***.)

→ ***Normal voiding pressure is fairly low (20 to 40 cm H_2O) but for men who suffer from prostatic obstruction of the urinary passage it may be over 100 cm H_2O.***

Measurement:

1. The pressure in the bladder is measured ***by passing a catheter*** with a pressure sensor to the bladder through the urinary passage (Urethra).

2. ***Direct cystometry***: A needle is inserted through the walls of the abdomen directly to the bladder.

During pregnancy, the weight of the fetus over the bladder increase the bladder pressure and causes frequent urination.

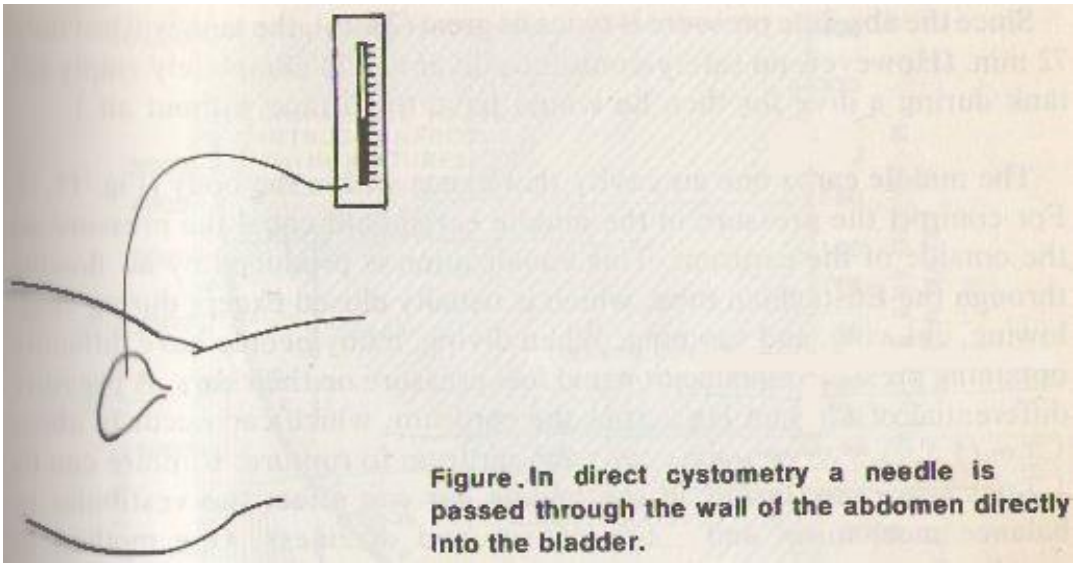


Figure. In direct cystometry a needle is passed through the wall of the abdomen directly into the bladder.