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L-9 Pressure in body

Pressure in body

The pressures in various parts of the body can be measured and often provide valuable medical indicators. In this section, we consider a few examples together with some of the physics that accompanies them.

Pressure (*P*) is the force applied perpendicular to the surface of an object per unit area over which that force is distributed.

$$P=F/A$$

Where: F is the force,   A is the cross sectional area

Gauge pressure (*gage* pressure) is the pressure relative to the ambient pressure.

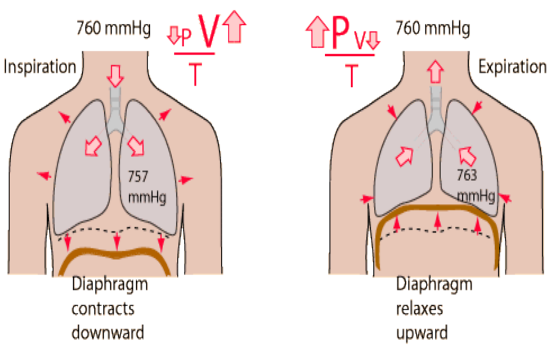
Negative Pressure

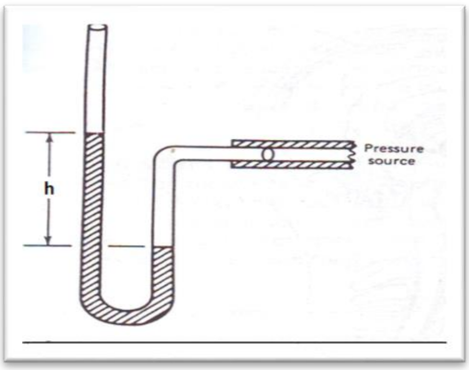
It is any pressure lower than atmospheric pressure. There are numbers of places in the body where the pressure is lower than atmospheric pressure or negative.

For example:

1. **The lung pressure during inspiration is a few centimeter of water negative, (when we breath inspire the pressure in the lungs must be lower than the atmospheric, When you inhale, the diaphragm and muscles between your ribs contract, creating a negative pressure—or vacuum—inside your chest cavity. The negative pressure draws the air that you breathe into your lungs.)**

2. **A person drink through a straw the pressure in his mouth must be negative.**





Pressure in fluid

- **An instrument that measures pressure is called a manometer.**
- **The pressure P under a column of liquid can be calculated from the following law:**

$$P= \rho g h$$

Where the: ρ: is the density of the liquid
g: is the acceleration due to the gravity
h: is height of the column

Blood Pressure

Next to taking a person's temperature and weight, measuring blood pressure is the most common of all medical examinations. Control of high blood pressure is largely responsible for the significant decreases in heart attack and stroke fatalities achieved in the last three decades.

Blood Pressure ;The force of circulating blood on the walls of the arteries

The common clinical instrument used in measuring blood pressure is the sphygmomanometer.

In humans, blood pressure is usually measured indirectly with a special cuff over the brachial artery (in the arm) or the femoral artery (in the leg). There are two pressures measured:

(1) the systolic pressure (the higher pressure and the first number recorded), which is the force that blood exerts on the artery walls as the heart contracts to pump the blood to the peripheral organs and tissues,

(2) the diastolic pressure (the lower pressure and the second number recorded), which is residual pressure exerted on the arteries as the heart relaxes between beats.

Common arterial blood pressure measurements typically produce values of 120 mm Hg and 80 mm Hg, respectively, for systolic and diastolic pressures. Both pressures have health implications.

Hypertension is diagnosed if, when it is measured on two different days, the systolic blood pressure readings on both days is ≥140 mmHg and/or the diastolic blood pressure readings on both days is ≥90 mmHg.

Hypotension, or low blood pressure, is a decrease in systemic blood pressure below accepted low values. While there is not an accepted standard hypotensive value, pressures less than 90/60 are recognized as hypotensive

The pressure differences in the circulation system are caused by blood flow through the system as well as the position of the person.

For a person standing up, the pressure in the feet will be larger than at the heart due to the weight of the blood ($P = h\rho g$). If we assume that the distance between the heart and the feet of a person in an upright position is 1.4 m, then the increase in pressure in the feet relative to that in the heart (for a static column of blood) is given by :

$$\Delta P=\Delta h\rho g= (1.4\ \text{m})\ (1050\ \text{kg/m}^3)\ (9.80\ \text{m/s}^2) =1.4\times10^4\ \text{Pa}=108\ \text{mm Hg}$$

- **Standing a long time can lead to an accumulation of blood in the legs and swelling.**
- **This is the reason why soldiers who are required to stand still for long periods of time have been known to faint.**
- **Elastic bandages around the calf can help prevent this accumulation and can also help provide increased pressure to enable the veins to send blood back up to the heart.**
- **For similar reasons, doctors recommend tight stockings for long-haul flights.**

Pressure inside the skull

- **The brain contains approximately 150cm^{3}of cerebral spinal fluid (CSF) in a series of inter connected openings called ventricles**

CSF (brain) ⟶ ventricles ⟶ spinal column ⟶ 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.**

Hydrocephalus is a condition in which an accumulation of cerebrospinal fluid (CSF) occurs within the brain.

A brain injury or some other health problem can cause growing pressure inside the skull. This dangerous condition is called increased intracranial pressure (ICP). It can lead to a headache. It can also further injure the brain or spinal cord.

What causes increased ICP?

Causes of increased ICP are:

- **Hydrocephalus, which is an abnormal buildup of cerebrospinal fluid. This is the fluid around the brain and spinal cord.**
- **Bleeding into the brain**
- **Swelling in the brain**
- **Aneurysm**
- **Blood pooling in some part of the brain**
- **Brain or head injury**
- **Brain tumor**
- **Infections such as encephalitis or meningitis**
- **High blood pressure**
- **Stroke**

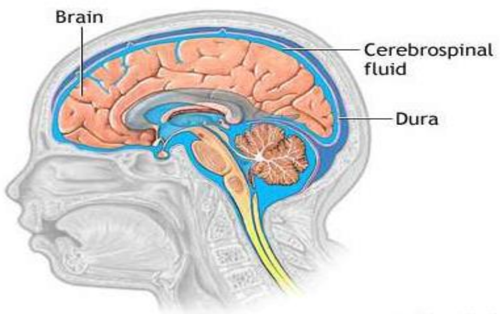
The CSF pressure, measured at lumbar puncture (LP), is 100-180 mm of H_2O (8-15 mm Hg) with the patient lying on the side and 200-300 mm of H_2O with the patient sitting up.

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. Transillumination is a test used to identify abnormalities in an organ or body cavity. The test is performed in a dark room, with a bright light shined at a specific body part to see the structures beneath the skin (through the body cavity or organ). Make use of the light –scattering properties of the rather clear CSF inside the skull.



Pressure in the Eye

- **The shape of the eye is maintained by fluid pressure (The clear fluids in the eye ball (aqueous and vitreous humors) that transmit the light to the retina), called *intraocular pressure* IOP, which is normally in the range of 12.0 to 24.0 mm Hg**
- **When the circulation of fluid in the eye is blocked. The partial blockage of the drain system occurs), it can lead to a buildup in pressure, a condition called *glaucoma*.**
- **When the eye pressure IOP > normal , ocular hypertension (no signs of glaucoma) .**
- **When the IOP>> normal (Elevated IOP)**

, the pressure increase of restrict the blood supply to the retina then affect the vision. This condition, called glaucoma.

Glaucoma: (moderate -tunnel vision) (severe -blindness)

People over 40 years of age are at greatest risk of developing glaucoma and should have their intraocular pressure tested routinely.

The net pressure can become as great as 85.0 mm Hg, an abnormally large pressure that can permanently damage the optic nerve. To get an idea of the force involved, suppose the back of the eye has an area of 6.0 cm^2, and the net pressure is 85.0 mm Hg. Force is given by $F = PA$.

To get F in newtons, we convert the area to m^2 ($1\ m^2 = 10^4\ cm^2$). Then we calculate as follows:

$$F=h\rho gA=(85.0\times10^{-3m})(13.6\times10^{3}kg/m^{3})(9.80\ m/s^{2})(6.0\times10^{-4}m^{2})=6.8\ N$$

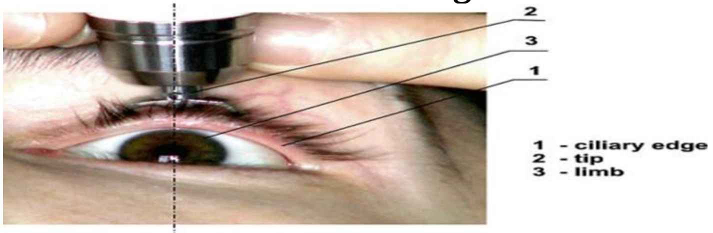
This force is the weight of about a 680-g mass. A mass of 680 g resting on the eye, would be sufficient to cause it damage. (A normal force here would be the weight of about 120 g, less than one-quarter of our initial value.)

Measuring the eye pressure

Most measurements involve exerting a force on the (anesthetized) eye over some area (a pressure) and observing the eye's response. A noncontact approach uses a puff of air and a measurement is made of the force needed to indent the eye. If the intraocular pressure is high, the eye will deform less and rebound more vigorously than normal. Excessive intraocular pressures can be detected reliably and sometimes controlled effectively.

1-By feel the physicians: estimate the pressure inside the eye by feel as they pressed on the eye with their fingertips. A normal eye should feel a bit like a tomato that is just ripe : not solid, nor very soft. It is important to compare the two eyes with one other. An eye with very high IOP will feel abnormally hard and solid

2-By the tonometer: an instrument is used to measure intraocular pressure (IOP). Tonometry is a test to measure the pressure inside your eyes. The test is used to screen for glaucoma. It is also used to measure how well glaucoma treatment is working.



The intraocular eye pressure can be read with a tonometer.