Types of Pressure in the Human Body

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ABSTRACT

Blood pressure is the force of blood pushing against the walls of blood vessels through which it moves to supply all the body's tissues and organs with food, oxygen, water, and enzymes in what is known as blood circulation. Blood circulation begins with the contraction of the heart muscle to forcefully push all its blood contents, which in turn moves from the heart to the aorta, the largest artery in the human body, and from there to the rest of the arteries. Then the heart relaxes to allow it to be filled with a new amount of blood packed with oxygen, so that it contracts again, pushing a new charge to the aorta. Again, and so on. Medical statistics show the great importance of maintaining blood pressure at an average of 115/75 mmHg, and that exceeding this limit leads to stress on the heart and kidneys, and that high blood pressure may lead to a stroke or early infertility in men.

Keywords: Blood pressure , heart and kidneys , Human Body

Introduction

Participating

Pressure is the vertical force acting per unit area.

and it is expressed by the following mathematical relationship:

pressure = force / area the unit of pressure is Newton / m^2,

and it is called pascal (SI)

The pascal (Pa) is a unit of pressure in the International System adopted by SI since 1971, named after the French mathematician Blaise Pascal.

and pressure is a standard quantity expressed as an amount It is not a direction, and the smaller the area, a small amount of force can cause more pressure, as in the case of a knife, so the relationship between pressure and area is inverse.

Units of pressure measurement There are several units that can be used to measure pressure:

1. Bar: It is equal to 1 x 105 Pa.
2. Millibar (mbar): It is equal to 100 Pa.
3. Hectopascal (hPa): It is equal to 100 Pa.
4. One millimeter of mercury (mmHg): equal to 133,322 Pa.

Pressure in the body

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. The pressures in various parts of the body can be measured and often provide valuable medical indicators.

Typical Pressures in Humans

Body system	**Gauge pressure in mm Hg**
Maximum (systolic)	100–140
Minimum (diastolic)	60–90
Blood pressure in large veins	4–15
Eye	12–24
Brain and spinal fluid (lying down)	5–12
While filling	0–25
When full	100–150
Chest cavity between lungs and ribs	−8 to −4
Inside lungs	−2 to +3
Esophagus	−2
Stomach	0–20
Intestines	10–20
Middle ear	<1

Blood Pressure

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. When systolic pressure is chronically high, the risk of stroke and heart attack is increased. If, however, it is too low, fainting is a problem. Systolic pressure increases dramatically during exercise to increase blood flow and returns to normal afterward. This change produces no ill effects and, in fact, may be beneficial to the tone of the circulatory system. Diastolic pressure can be an indicator of fluid balance. When low, it may indicate that a person is hemorrhaging internally and needs a transfusion. Conversely, high diastolic pressure indicates a ballooning of the blood vessels, which may be due to the transfusion of too much fluid into the circulatory system. High diastolic pressure is also an indication that

blood vessels are not dilating properly to pass blood through. This can seriously strain the heart in its attempt to pump blood.

Blood leaves the heart at about 120 mm Hg but its pressure continues to decrease (to almost 0) as it goes from the aorta to smaller arteries to small veins 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

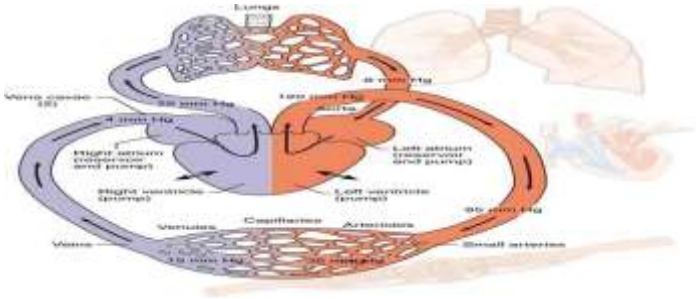
$$\Delta P = \Delta h \rho g = (1.4\ \text{m})(1050\ \text{kg/m3})(9.80\ \text{m/s2}) = 1.4 \times 104\ \text{Pa} = 108\ \text{mm}$$

Blood pressure may also be measured in the major veins, the heart chambers, arteries to the brain, and the lungs. But these pressures are usually only monitored during surgery or for patients in intensive care since the measurements are invasive. To obtain these pressure measurements, qualified health care workers thread thin tubes, called catheters, into appropriate locations to transmit pressures to external

measuring devices. The heart consists of two pumps—the right side forcing blood through the lungs and the left causing blood to flow through the rest of the body (Figure 1). Right-heart failure, for example, results in a rise in the pressure in the vena cavae and a drop in pressure in the arteries to the lungs. Left-heart failure results in a rise in the pressure entering the left side of the heart and a drop in aortal pressure. Implications of these and other pressures on flow in the circulatory system will be discussed in more detail in **Fluid Dynamics and Its Biological and Medical Applications**.

TWO PUMPS OF THE HEART

The heart consists of two pumps—the right side forcing blood through the lungs and the left causing blood to flow through the rest of the body.

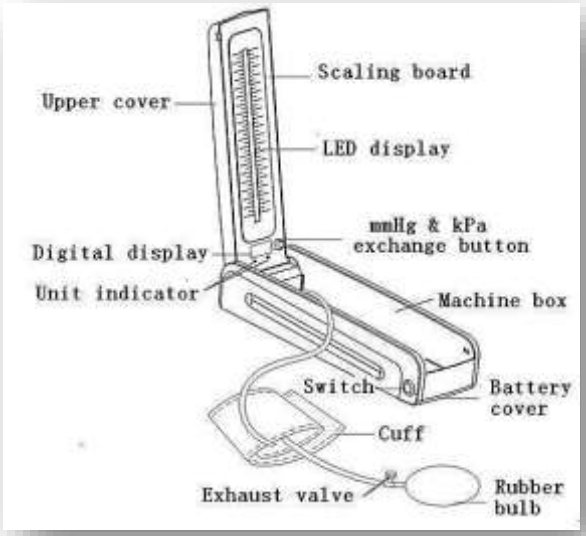


Types of blood pressure monitors: 1- Mercury sphygmomanometer

A mercury sphygmomanometer is a device used to measure systolic and diastolic blood pressure by raising the

pressure inside the cuff of the device and then gradually lowering it, and it consists of the following:

- A tube containing mercury next to a graduated scale.
- An inflatable, flexible cuff that wraps around the arm.
- A tool for inflating air into the cuff, and a valve for deflating it.
- Pressure sensor inside the cuff.
- A stethoscope to hear the flow of blood inside an artery, the sound of blood flowing is called Korotkoff sounds.



And with the contraction of the heart, the passage of blood in the arteries leads to an increase in pressure, and this is known as the systolic blood pressure, then this is followed by a decrease in pressure while the heart is preparing for another contraction, and this is known as the diastolic blood pressure, and it is usually expressed by mentioning the value of the systolic pressure over the value of the value of the diastolic pressure, for example say 120 over 80; Where 120 represents the systolic pressure reading, and 80 represents the diastolic pressure, and it is indicated that there are two types of manual pressure measurement devices, which are the aneroid sphygmomanometer, and the other is the mercury sphygmomanometer, and they work in the same way Approximately, but the aneroid pressure device needs to be calibrated periodically.

How to use a mercury pressure gauge

The use of a mercury pressure gauge requires the examiner to have a healthy ability to make coordinated movements in the hands to inflate and deflate air and wrap the tape around the arm, and the integrity of his senses of hearing and sight and the absence of weakness in them. As for the steps for conducting the measurement, we show them as follows:

- Prepare to measure your blood pressure by sitting quietly for 3-5 minutes before starting the measurement.
- Wrap the cuff around the arm above the bend of the elbow or elbow by approximately 2.5 cm, taking care not to wrap the cuff over the clothes, and ensure that the cuff is wrapped tightly and evenly around the arm from all sides, and not exceeding an amount that allows two fingers to pass through the upper end of the cuff, In order to ensure that the cuff is placed correctly, no pinching or stinging sensation should be felt in the skin when the cuff is inflated.
- Place the stethoscope on the skin under the cuff.
- Place the earpieces of the stethoscope in the ear, making sure that they are directed towards the front of the nose.
- Putting the scale that will show the result in the palm of the hand to be able to see it clearly.
- Pressing the air pump with the other hand several times in a row, without stopping, to inflate the cuff until the reading reaches a level that exceeds the normal systolic blood pressure by approximately 30 degrees, while making sure to inflate the cuff quickly.
- Stop inflating and slowly open the air valve to empty the air from the cuff at a rate that leads to a drop in the pressure indicator of approximately 2 millimeters per second, while listening to the heart sound. It is indicated that the reading on the scale should be noted when hearing the first heartbeat; As this reading reflects the systolic blood pressure, while the

diastolic blood pressure refers to the reading at which the pulse ceases to be heard permanently.

- Relax and wait about two minutes before measuring the pressure rate again, then recording the results.

Mercury sphygmomanometer readings

- Normal blood pressure: or ideal blood pressure, and ranges between 90/60 mm Hg and 120/80 mm Hg.
- Low blood pressure: This means that blood pressure readings are less than 90/60 mm Hg.
- High blood pressure: (in English: Elevated blood pressure), and in this case, the systolic blood pressure values range between 120-129 mm Hg, and the diastolic blood pressure is no more than 80 mm Hg, and here it is indicated that the necessary measures should be taken to control blood pressure. And prevent further rise, otherwise the condition may worsen and the pressure will rise more.

2-The electronic blood pressure monitor has several types:

It is an electronic device for measuring blood pressure that combines the scale and the stethoscope at the same time. The most important features of the device

- A device used to measure pressure placed on the upper arm
- It has a large and clear LCD screen
- It has a large arm link for user convenience and an alert if the link is in the wrong position
- Contains an alert in case of irregular heartbeat
- It can be used by more than one person and can store up to 60 readings
- Battery operated and can be charged at any time

Ambulatory Blood Pressure Monitor (ABPM)

An ambulatory sphygmomanometer (ABPM) is used when your blood pressure is measured while you are on the move, and live your normal daily life

Twenty-four hours after installing the display, you must return to the clinic for a medical staff member to remove it and the clinic staff will decode the display in order to obtain a computer report. This report will include all recorded blood pressure readings, in addition to the average pressure during the day and night hours. Some clinic staff may give

you a copy of the report, but others may prefer to send the report to the doctor so that you can discuss the matter in more detail.

Causes of high blood pressure:

- **Genetic factors.**
- **Smoking.**
- **Obesity and overweight.**
- **Lack of movement and physical activity.**
- **Tension and psychological pressure.**
- **Excessive intake of foods rich in salt.**
- **Advance age and pregnancy.**
- **Infection with some diseases such as chronic kidney disease, adrenal and thyroid gland disorders, or high parathyroid activity.**

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symptoms of high blood pressure are as follows:

- Headache and redness of the face.
- Vertigo and dizziness.
- Tinnitus.
- Fainting and frequent urination.
- Sudden weight gain.
- Muscle spasms.
- Tachycardia

causes of low blood pressure

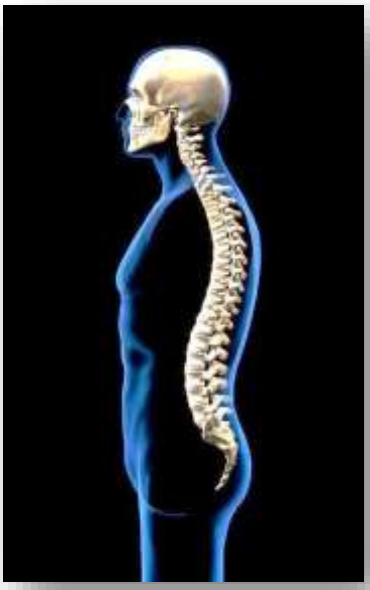
- Exaggerating the practice of yoga and meditation.
- Side effects of some medicines.
- Hormonal changes.
- Low blood volume and anemia.
- expansion of blood vessels.
- irregular heartbeat.
- Exposure to some health problems such as problems that occur in the heart or endocrine glands.
- Not drinking enough fluids due to fasting, diarrhea, excessive vomiting, or taking diuretics.

Symptoms of low blood pressure

- hard breathing.
- Chest pain.
- Indigestion and urine.
- The appearance of black stools.
- Connective tissue disorder.
- arrhythmia.
- Headache and neck stiffness.
- Severe pain in the upper back.
- Cough with phlegm.
- Loss of consciousness and extreme fatigue.
- Blurred vision.

Chapter Two

Spinal Column and Skull



Normally, there is a 5- to 12-mm Hg pressure in the fluid surrounding the brain and filling the spinal column. This cerebrospinal fluid serves many purposes, one of which is to supply flotation to the brain. The buoyant force supplied by the fluid nearly equals the weight of the brain, since their densities are nearly equal. If there is a loss of fluid, the brain rests on the inside of the skull, causing severe headaches, constricted blood flow, and serious damage. Spinal fluid pressure is measured by means of a needle inserted between vertebrae that transmits the pressure to a suitable measuring device.

Spinal Column and Skull

These pressures are the largest in the body, due both to the high values of initial force, and the small areas to which this force is applied, such as in the joints.. For example, when a person lifts an object improperly, a force of 5000 N may be created between vertebrae in the spine, and this may be applied to an area as small as 10 cm^2. The pressure created is $P = F/A$ = (5000 N)/($10^{-3} m^2$) = 5.0×10^6 N/m^2 or about 50 atm! This pressure can damage both the spinal discs (the cartilage between vertebrae), as well as the bony vertebrae themselves. Even under normal circumstances, forces between vertebrae in the spine are large enough to create pressures of several atmospheres. Most causes of excessive pressure in the skeletal system can be avoided by lifting properly and avoiding extreme physical activity. (See Forces and Torques in Muscles and Joints.)

There are many other interesting and medically significant pressures in the body. For example, pressure caused by various muscle actions drives food and waste through the digestive system. Stomach pressure behaves much like bladder pressure and is tied to the sensation of hunger. Pressure in the relaxed esophagus is normally negative because pressure in the chest cavity is normally negative. Positive pressure in the stomach may thus force acid into the esophagus, causing “heartburn.” Pressure in the middle ear can result in significant force on the eardrum if it differs greatly from

atmospheric pressure, such as while scuba diving. The decrease in external pressure is also noticeable during plane flights (due to a decrease in the weight of air above relative to that at the Earth's surface). The Eustachian tubes connect the middle ear to the throat and allow us to equalize pressure in the middle ear to avoid an imbalance of force on the eardrum.

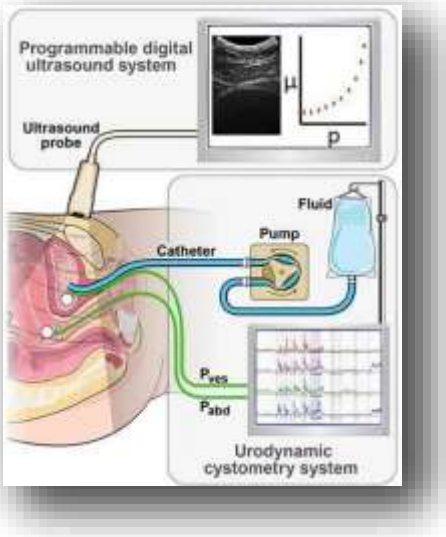
Chapter Three

Bladder Pressure This bodily pressure is one of which we are often aware. In fact, there is a relationship between our awareness of this pressure and a subsequent increase in it. Bladder pressure climbs steadily from zero to about 25 mm Hg as the bladder fills to its normal capacity of 500 cm^3. This pressure triggers the *micturition reflex*, which stimulates the feeling of needing to urinate. What is more, it also causes muscles around the bladder to contract, raising the pressure to over 100 mm Hg, accentuating the sensation. Coughing, straining, tensing in cold weather, wearing tight clothes, and experiencing simple nervous tension all can increase bladder pressure and trigger this reflex. So can the weight of a pregnant woman's fetus, especially if it is kicking vigorously or pushing down with its head!

Bladder pressure can be measured by a catheter or by inserting a needle through the bladder wall and transmitting the pressure to an appropriate measuring device. One hazard of high bladder pressure (sometimes created by an obstruction), is that such pressure can force urine back into the kidneys, causing potentially severe damage.

Measurement of pressure in the bladder

In clinical practice, pressures are often measured indirectly through a fluid line where pressure is transmitted from the organ of interest to a remote, externally localized transducer. Transmission through a fluid line represents a delay in the measurements.



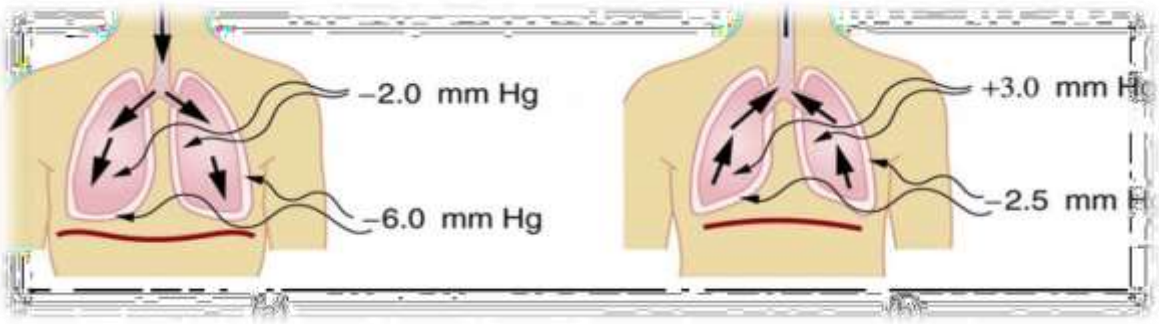
Pressure measurement through a fluid column is also prone to artefacts from patient movement. Both due to patient comfort and risk of infections, the pressure examination is mostly limited to a short period of time, for example, during or after surgery, and only instantaneous values are recorded. Therefore,

conventional pressure measurement methods represent only the best achievable measure of the patient's condition.

Pressure Associated with the Lungs

The pressure inside the lungs increases and decreases with each breath. The pressure drops to below atmospheric pressure (negative gauge pressure) when you inhale, causing air to flow into the lungs. It increases above atmospheric pressure (positive gauge pressure) when you exhale, forcing air out. Lung pressure is controlled by several mechanisms. Muscle action in the diaphragm and rib cage is necessary for inhalation; this muscle action increases the volume of the lungs thereby reducing the

pressure within them Figure 3. Surface tension in the alveoli creates a positive pressure



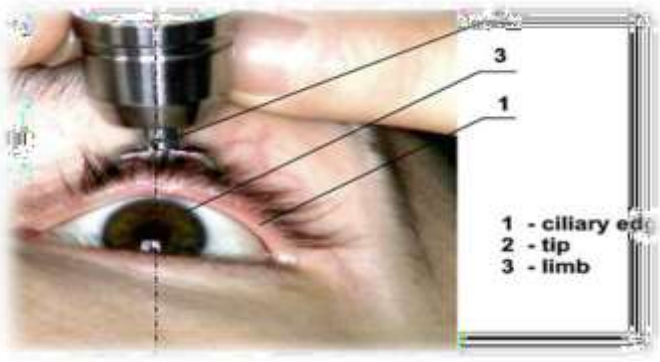
opposing inhalation. (See **Cohesion and Adhesion in Liquids: Surface Tension and Capillary Action**.) You can exhale without muscle action by letting surface tension in the alveoli create its own positive pressure. Muscle action can add to this positive pressure to produce forced exhalation, such as when you blow up a balloon, blow out a candle, or cough. The lungs, in fact, would collapse due to the surface tension in the alveoli, if they were not attached to the inside of the chest wall by liquid adhesion. The gauge pressure in the liquid attaching the lungs to the inside of the chest wall is thus negative, ranging from −4 to −8 mm Hg during exhalation and inhalation, respectively. If air is allowed to enter the chest cavity, it breaks the attachment, and one or both lungs may collapse.

Suction is applied to the chest cavity of surgery patients and trauma victims to reestablish negative pressure and inflate the lungs.

Pressure in the Eye

The shape of the eye is maintained by fluid pressure, called *intraocular pressure*, which is normally in the range

of 12.0 to 24.0 mm Hg. When the circulation of fluid in the eye is blocked, it can lead to a buildup in pressure, a condition called *glaucoma*. 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:

$$F=h\rho gA=(85.0\times10-3m)(13.6\times103\ kg/m3)(9.80\ m/s2)(6.0\times10-4m2)=6.8\ N$$

This force is the weight of about a 680-g mass. A mass of 680 g resting on the eye (imagine 1.5 lb resting on your 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.)

People over 40 years of age are at greatest risk of developing glaucoma and should have their intraocular pressure tested routinely. 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 (Figure 2). 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.

Chapter Four pregnancy pressure

It is a condition of narrowing of blood vessels that occurs during pregnancy in the second half and occurs in both the large and small arteries, which is called preeclampsia.

The incidence of pregnancy pressure increases with one of the following factors:

Skin color, twin pregnancies, maternal age less than 20 years and more than 40 years, poor economic situation resulting in malnutrition, increased fluid around the fetus and heart disease and blood sugar. Symptoms:

1. High blood pressure above the normal value that a woman is accustomed to as a pressure reading

2. The presence of protein in the urine

3. Swelling in the lower extremities as a result of the accumulation of fluid between the cells

4. Sudden weight gain

The mechanism of occurrence of the disease:

Increasing the amount of blood returning from the heart leads to the occurrence of wounds inside the arteries, which leads to an increase in the secretion of prostaglandins that lead to narrowing of the blood vessels, and then the blood pressure increases dramatically.

Effect of high blood pressure on body systems:

1. The pancreas: the perfusion of the pancreas decreases as a result of stomach pain and an increase in amylase-creatinine.

2. The eyes: narrowing occurs in all the arteries in the body, including the arteries of the eyes, which leads to a change in vision.

3. Placenta: Lack of ischemia leads to a lack of access to nutrients and oxygen to the fetus.

4. The kidneys: the permeability of the kidney membrane increases, which leads to allowing protein to pass into the urine, and this is known by examining a urine sample

5. The extremities: the sodium element increases, which leads to the occurrence of swelling in the feet significantly, in addition to the swelling that may occur in the tissues of the brain and lungs if the amount of fluid exceeds the permissible limit.

Classifications of pregnancy pressure:

1. Initial pregnancy pressure

2. Mild preeclampsia

3. Severe preeclampsia

4. Convulsions 1. Preeclampsia: It is a high blood pressure of 140/90 mm Hg, in this type there is no need to use treatment and no protein is

observed in the urine 2. Mild preeclampsia: It is a high blood pressure of more than 140/90 mm Hg and less From the value at which convulsions occur. In this case we can find out if the pressure is high by calculating the pressure and if the value

If the systolic pressure is more than 30 mm Hg and the diastolic pressure is more than 15 mm Hg than the normal value, it is considered mild

preeclampsia.

The percentage of protein in the urine at this stage is estimated at 1 gram per liter. At this stage, fluids begin to collect in the upper extremities, and urine output for 24 hours is estimated at 400-600 ml. 3. Severe pre- eclampsia: pressure rises to 110/160 mm Hg, loss of approximately 4-5 grams per liter of protein, and a large accumulation of fluid occurs in the

face, hands and jaw.

Its symptoms include severe stomach pain, vomiting and nausea, decreased urine output, vision changes, liver disorders and a decrease in the number of blood platelets.

At this stage, the death rate of mothers reaches 20% for several reasons, including cerebral hemorrhage, collapse of blood vessels and kidney failure, and the death rate of children reaches 25%.

Ear Pressure

Ear pressure is the feeling of fullness and stuffiness in the ear.

It occurs when the eustachian tube is blocked or is not functioning correctly.

The eustachian tube is a structure in the ear that connects the middle ear with the upper throat and back of the nose.

It is responsible for regulating inner ear pressure and draining fluid from the middle ear to make it less prone to infections.

Causes

- **Sinusitis**

  The sinuses are air-filled cavities in the head responsible for producing mucus, which helps to keep the nasal passage clean. When mucus accumulates in the sinuses, it causes congestion. Sinus congestion can be caused by viral infections, bacterial infections, and allergies

- **Ear infections**

  Ear infections can cause the feeling of fullness in the ear.

  The pressure experienced with middle ear infections also known as otitis media, occurs when fluid is behind the eardrum and puts pressure on the eardrum.

  Aside from ear pressure, other symptoms may include hearing loss, fever, ear pain, and ear discharge

- **Changes in altitude**

A sudden change in altitude can block the Eustachian tube.

In this case, the tube is unable to quickly equalize the pressure of the middle ear with the immediate environment.

It commonly occurs when doing things like flying on a plane and while scuba diving Some symptoms can include ear pressure, headache reduced sense of smell, yellow or green mucus, and pain and tenderness around cheeks, eyes, or forehead.

- **Allergies**

In many areas in the United States, nasal allergy, also known as allergic rhinitis, is a major cause of chronic blockage of the Eustachian tube

People sensitive to allergens such as pollen can experience inflammation in the membrane lining of the Eustachian tube related to that.

This leads to abnormal ear pressure and may cause fluid build-up, itching, and ear pain.

- **Earwax buildup**

Oil glands naturally produce ear wax in the ear canal.

It usually moves to the opening of the ear where it falls out or is washed out, but some people produce excess wax that builds up and blocks the ear.

This can cause ear pressure, muffled hearing, and itching.

- **Barotrauma**

Ear barotrauma implies changes in the ear due to air or water pressure.

Most people experience barotrauma at some point in their lives. It can occur due to changes in altitude, nasal congestion swelling of the throat, and blockage of the Eustachian tube present before birth. Barotrauma can cause ear pressure, pain, dizziness and hearing loss.

However, hearing loss from barotrauma is often temporary

- **Foreign object in the ear**

Depending on how deep they get, foreign objects trapped in the ear canal can create pressure in the ear.

This is more common among children who tend to put things in their mouth, nose, and ear out of curiosity.

Items that may get stuck in the ear include beads, crayons, small batteries, and toys.

Other than ear pressure, some of the symptoms include ear discharge, ear pain, and hearing loss.

- Meniere's disease

  is an inner ear disorder that affects both hearing and balance

  It typically occurs in only one ear but may later develop in both ears. The cause of Meniere's disease is unknown.

  However, some of its symptoms include ear pressure, severe dizziness (https://www.khealth.com/learn/symptom/dizziness/), ringing in the ear, and hearing loss.

- Acoustic neuroma

  Acoustic neuroma is a non-cancerous tumor that affects the nerves responsible for hearing and balance.

  Although it is a slow-growing tumor, it can press against the brain, turning it into a life-threatening condition if it grows large.

  Symptoms can include ear pressure, loss of balance, ringing in the ear, dizziness, and loss of hearing on one side

- Fungal ear infection
- Cholesteatoma

  is a skin cyst that occurs in the middle ear.

  It can be a defect present before birth or may develop after a chronic ear infection.

  The skin cyst may become infected or grow if left untreated.

  It may also lead to complications such as meningitis, facial paralysis, and in rare cases, brain abscess.

Its symptoms include ear pressure, dizziness, ear discharge, and hearing loss.

- **Temporomandibular joint disorders**

  Temporomandibular joint disorders affect the joints that connect the lower jaw to the skull.

  The cause of this condition is not fully known.

  Some of the symptoms include discomfort in the ear, headache, and pain around the jaw.

Hearing aids working principle:

Tympanometer: The pressure in the middle ear is measured with a probe inserted into the outer ear canal.

The result is a graph and pressure value. This graph usually has an upper value called the peak and it should be at zero.

If there is a peak but not higher than 0, there is low pressure and slight membrane collapse.

If there is an upper value but it is not higher than zero, this means that there is a pressure drop and a significant collapse of the

diaphragm

A pressure value from -50 to +50 is considered normal.

Low pressure shows the problems of otitis media, allergies or fevers that appear, especially in children

Audiometer: It is the sending of sound to the patient's ear through a stethoscope.

When the patient hears a beep, he presses the button on his hand and gives a signal. This will determine the level of sound heard by the patient.

This measurement determines the level of hearing in the airway and bone duct as well. Airway measurements provide information about the auditory ducts from the ear to the brain.

The bone pathway gives information starting in the inner ear.

According to the airway and bone test, it gives information about the part causing the hearing loss. Hearing level is measured in decibels (dB). According to this test, the degree of hearing loss is determined.

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