Measurement of Blood Pressure

The heart supplies the organs and tissues of the body with blood. With every beat, it pumps blood intothe large blood vessels of the circulatory system. As the blood moves around the body, it puts pressureon the walls of the vessels. Blood pressure readings are made up of two values:

- **Systolic blood pressure** is the pressure when the heart beats – while the heart muscle is contracting (squeezing) and pumping oxygen-rich blood into the blood vessels.
- **Diastolic blood pressure** is the pressure on the blood vessels when the heart muscle relaxes. The diastolic pressure is always lower than the systolic pressure.

Blood pressure is measured in units of millimetres of mercury (mmHg). The readings are always givenin pairs, with the upper (systolic) value first, and followed by the lower (diastolic) value.

So, someone who has a reading of 132/88 mmHg (often spoken “132 over 88”) has a

- **Systolic blood pressure** of 132 mmHg.
- **Diastolic blood pressure** of 88 mmHg.
- **Hypertension –** high blood pressure: consistently >140/90mmHg
- **Hypotension –** low blood pressure: typically, a systolic reading of <90mmHg

Blood Pleasure can be measured in two ways:

- Manually, using the auscultatory method – this involves listening to arterial sounds.
- Automatically, using the oscillometer method – this detects variations in pressure oscillationsdue to arterial wall movement.

Both methods use a measuring device attached to an inflatable cuff that is placed around the patient’supper arm, inflated to occlude the artery under the cuff, and then released in a controlled manner.

BP is a variable haemodynamic phenomenon, and can be influenced by a range of factors

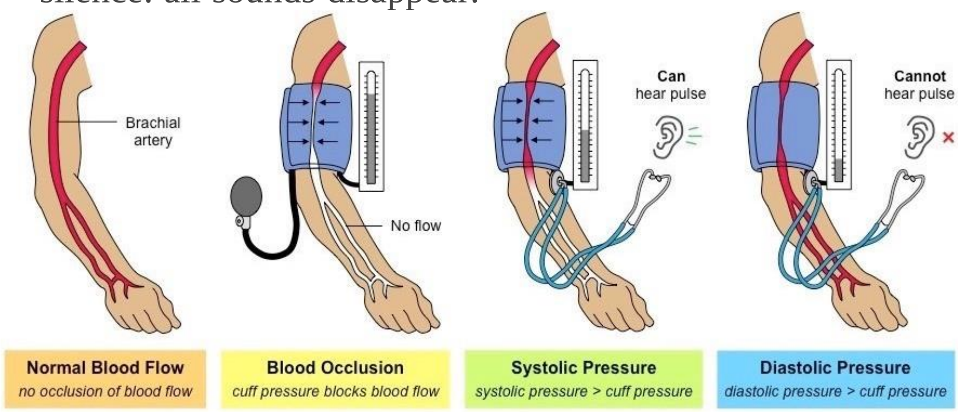
Factors that can cause a variation in blood pressure

- Emotional state
- Temperature
- Respiration
- Bladder distension
- Sudden change in posture
- Tobacco use
- Pain
- Exercise

Manual Auscultatory measurement

Manual BP measurement devices require the user to inflate the upper-arm cuff to occlude the brachial artery, then listen to the Korotkoff sounds through a stethoscope while the cuff is slowly deflated. When the cuff is slowly deflated, five different sound phases can be heard:

- Phase I – a thud;
- Phase II – a blowing or swishing noise;
- Auscultatory gap – in some patients, the sounds disappear for a short period;
- Phase III – a softer thud than in phase I;
- Phase IV – a disappearing blowing noise;
- Phase V – silence: all sounds disappear.



Devices that are generally used for manual BP measurement include:

- Aneroid sphygmomanometer – this replaces the mercury manometer with an aneroid (liquid-free) gauge that registers pressure using a bellows and lever system (O'Brien, 2015), and requires use of a stethoscope;
- Electronic sphygmomanometer – this battery-powered device replaces the mercury manometer with a pressure sensor and electronic display. The display may be numerical, or a circular or linear bargraph. No stethoscope is needed.

Automated measurement

Automated electronic BP devices

Most automated BP measurement devices in current clinical practice use the oscillometric method. Each arterial pulse wave results in a small rise and fall in the volume of the limb which, in turn, causes an increase then a decrease in the pressure within the encircling cuff. The oscillometric method relies on detection of variations in pressure oscillations due to arterial wall movement beneath an occluding cuff to calculate the systolic and diastolic BP readings

Cardiac Output

Cardiac output (CO) is the amount of blood pumped by the heart minute and is the mechanism whereby blood flows around the body, especially providing blood flow to the brain and other vital organs. The body's demand for oxygen changes, such as during exercise, and the cardiac output is altered by modulating both heart rate

(HR) and stroke volume (SV). As a result, the regulation of cardiac output is subject to a complex mechanism involving the autonomic nervous system, endocrine, and paracrine signalling pathways

Because every tissue in the body relies on the heart pumping blood for nourishment, any cardiovascular dysfunction has the potential to result in significant morbidity and mortality. The degree of functional impairment can be assessed by a variety of methods that guides diagnosis, prognosis, and treatment

Cardiac output, expressed in liters/minute, is the amount of blood the heart pumps in 1 minute. Cardiac output is logically equal to the product of the stroke volume and the number of beats per minute (heart rate).

Normal Output

It's different for different people, depending on their size. Usually, an adult heart pumps about 5 liters of blood per minute at rest. But when you run or exercise, your heart may pump 3-4 times that much to make sure your body gets enough oxygen and fuel.

How It's Measured

Your cardiac output is your heart beats per minute multiplied by the amount of blood pumped with each beat.

Your doctor can measure it in lots of ways.

Pulmonary artery catheter. Your doctor inserts this device into the artery that sends blood to the lungs to pick up oxygen.

Echocardiogram. This uses sound waves to make an image of your heart and blood flow through your heart.

Arterial pulse waveform analysis. These calculate the cardiac output from shock waves created by blood flow.

Low Output

If your heart doesn't pump enough blood to supply your body and tissues, it could signal heart failure. Low output also could happen after you've lost too much blood, had a severe infection called sepsis, or had severe heart damage.

High Output

Sometimes, sepsis, your body's response to blood infections that can lead to a dangerous drop in blood pressure and organ failure, can cause high cardiac output.

High output also can happen when your body lacks enough oxygen-carrying red blood cells, a condition called anemia. That makes your heart pump more blood faster. Another common cause is hyperthyroidism, which is when your thyroid gland makes more thyroid hormones than needed.

<u>Heart Rate</u>

Your heart rate, or pulse, is the number of times your heart beats in 1 minute. Heart rates vary from person to person. It's lower when you're at rest and higher when you exercise.

As you age, changes in the rate and regularity of your pulse can change and may signify a heart condition or other condition that needs to be addressed

The best places to find your pulse are the:

- wrists
- inside of your elbow
- side of your neck
- top of the foot
- To get the most accurate reading, put your finger over your pulse and count the number of beats in 60 seconds.
- Your **resting heart rate** is the heart pumping the lowest amount of blood you need because you're not exercising. If you're sitting or lying and you're calm, relaxed and aren't ill, your heart rate is normally between 60 (beats per minute) and 100 (beats per minute).
- But a heart rate lower than 60 doesn't necessarily signal a medical problem. It could be the resultof taking a drug such as a beta blocker. A lower heart rate is also common for people who get a lotof physical activity or are very athletic. Active people often have a lower resting heart rate (as lowas 40) because their heart muscle is in better condition and doesn't need to work as hard to maintain a steady beat. A low or moderate amount of physical activity doesn't usually change the resting pulse much.

How Other Factors Affect Heart Rate

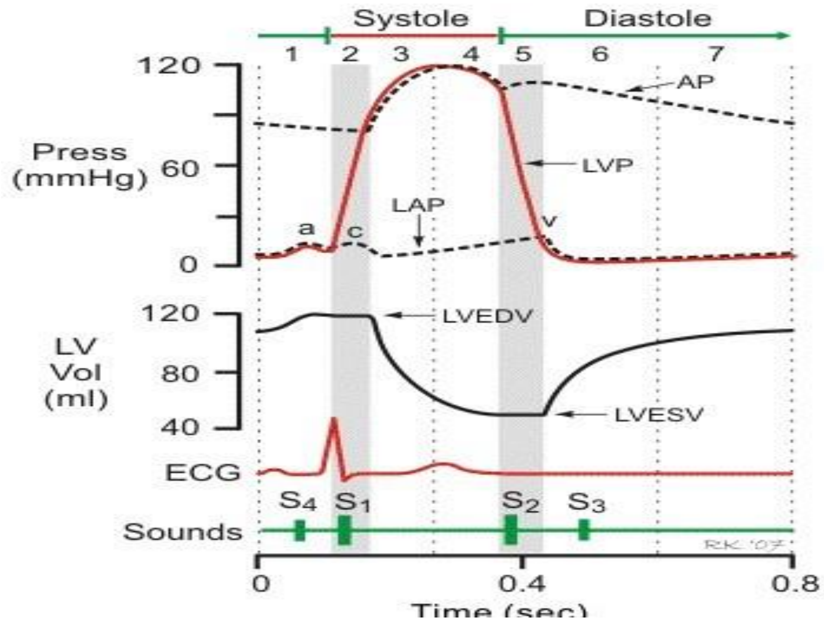
- **Air temperature:** When temperatures (and the humidity) soar, the heart pumps a little more blood, so your pulse rate may increase, but usually no more than five to 10 beats a minute.
- **Body position:** Resting, sitting or standing, your pulse is usually the same. Sometimes as you stand for the first 15 to 20 seconds, your pulse may go up a little bit, but after a couple of minutesit should settle down.
- **Emotions:** If you're stressed, anxious or "extraordinarily happy or sad" your emotions can raise your pulse.
- **Body size:** Body size usually doesn't change pulse. If you're very obese, you might see a higher resting pulse than normal, but usually not more than 100.
- **Medication use:** Meds that block your adrenaline (beta blockers) tend to slow your pulse, while too much thyroid medication or too high of a dosage will raise it.

<u>Heart Sound</u>

When a stethoscope is placed on the chest over different regions of the heart, there are four basic heart sounds that can be heard (listening to heart sounds is called cardiac auscultation). The sounds waves responsible for heart sounds (including abnormal sounds such as murmurs) are generated by vibrations induced by valve closure, abnormal valve opening, vibrations in the ventricular chambers, tensing ofthe chordae tendineae, and by turbulent or abnormal blood flow across valves or between cardiac chambers

The common mechanisms by which heart sounds are generated include

(1) opening or closure of the heart valves
(2) flow of blood through the valve orifice
(3) flow of blood into the ventricular chambers
(4) rubbing of cardiac surfaces.



The most fundamental heart sounds are the first and second sounds, usually abbreviated as S_1 and S_2. S_1 is caused by closure of the mitral and tricuspid valves at the beginning of isovolumetric ventricular contraction. S_1 is normally slightly split (~0.04 sec) because mitral valve closure precedes tricuspid valve closure; however, this very short time interval cannot normally be heard with a stethoscope so only a single sound is perceived. S_2 is caused by closure of the aortic and pulmonic valves at the beginning of isovolumetric ventricular relaxation. S_2 is physiologically split because aortic valve closure normally precedes pulmonic valve closure. This splitting is not of fixed duration. S_2 splitting changes depending on respiration, body posture and certain pathological conditions.

The third heart sound (S_3), when audible, occurs early in ventricular filling, and may represent tensing of the chordae tendineae and the atrioventricular ring, which is the connective tissue supporting the AV valve leaflets. This sound is normal in children, but when heard in adults it is often associated with ventricular dilation as occurs in systolic ventricular failure.
The fourth heart sound (S_4), when audible, is caused by vibration of the ventricular wall during atrial contraction. This sound is usually associated

with a stiffened ventricle (low ventricular compliance), and therefore is heard in patients with ventricular hypertrophy, myocardial ischemia, or in older adults.

Heart Sound	**Occurs during:**	**Associated with:**
S1	Isovolumetri ccontraction	Closure of mitral and tricuspid valves
S2	Isovolumetri crelaxation	Closure of aortic and pulmonic valves
S3	Early ventricular filling	Normal in children; in adults, associated with ventricular dilation (e.g.ventricular systolic failure)
S4	Atrial contraction	Associated with stiff, low compliant ventricle (e.g., ventricularhypertrophy; ischemic ventricle)