PATIENT MONITORING SYSTEMS

BP measurement

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of blood vessels. Blood pressure usually refers to the arterial pressure in the systemic circulation. It is usually measured at a person's upper arm. Blood pressure is usually expressed in terms of the systolic (maximum) pressure over diastolic (minimum) pressure and is measured in millimeters of mercury (mm Hg). It is one of the vital signs along with respiratory rate, heart rate, oxygen saturation, and body temperature. Normal resting blood pressure in an adult is approximately 120/80 mm Hg.

The highest pressure in the arteries, produced as a result of ventricular contraction is known as the systolic blood pressure. The lowest pressure in the arteries, produced as a result of ventricular relaxation is known as the diastolic blood pressure. The difference between the systolic and the diastolic pressure is known as the pulse pressure. The average effective arterial pressure forcing blood through the organs is known as the mean arterial blood pressure. This is determined by adding one-third of the pulse pressure to the diastolic pressure.

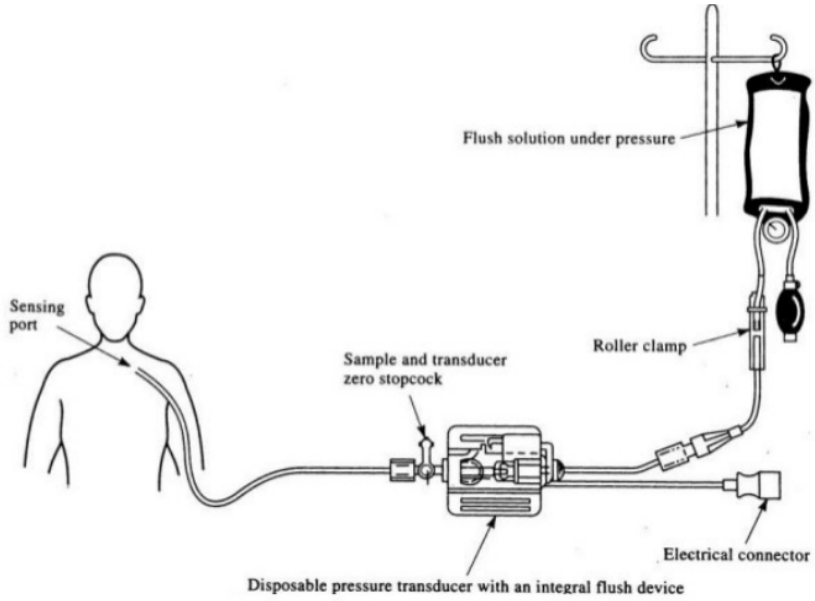
Direct and indirect method

Two methods for measuring a blood pressure exist, the direct and indirect method.

Direct BP measurement

In the direct method, a fluid-filled cannula is inserted into an artery and the direct, head-on pressure of the blood is measured with a pressure transducer.

The direct method is the criterion standard and consists of using an intra-arterial catheter to obtain a measurement.



Indirect BP measurement

Sphygmomanometer/Ausculatory method

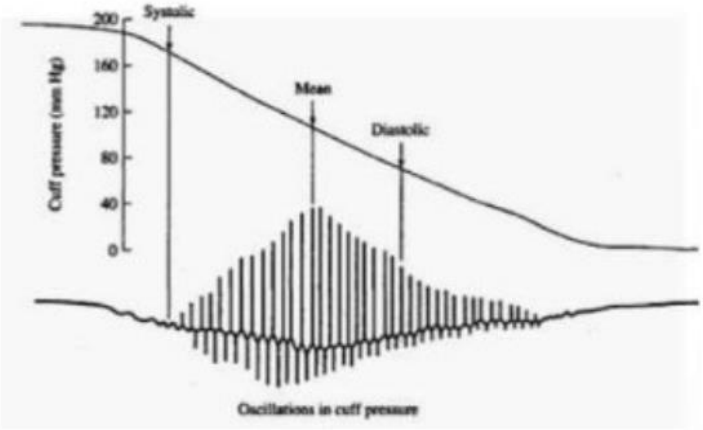
Pressure is applied externally to an artery occluding it and stopping blood flow. Then the blood pressure is determined by listening to various arterial sounds (korotkoff sounds) that result when the external pressure is reduced and the blood begins to flow again. This is called the Auscultatory Method since the detection of sound is called "auscultation".

In both indirect methods pressure is applied externally to an artery using an instrument called a sphygmomanometer. It consists of an inflatable rubber bag (cuff), a rubber bulb for introducing air into the cuff, and a mercury or aneroid manometer for measuring the pressure in the cuff. The cuff size used varies depending on the circumference of the arm.

Human blood pressure is most commonly measured in the brachial artery of the upper arm. In addition to being a convenient position for taking measurements, it has the added advantage of being at approximately the same level as the heart so that pressures obtained closely approximate the pressures in the aorta leaving the heart. This allows the blood pressure to be correlated with heart activity.

Oscillometric Method

Oscillometric measurement devices use an electronic pressure sensor with a numerical readout of blood pressure. In most cases the cuff is inflated and released by an electrically operated pump and valve, which may be fitted on the the upper arm. Initially the cuff is inflated to a pressure in excess of the systolic arterial pressure, and then the pressure reduces to below diastolic pressure. Once the blood flow is present, but restricted, the cuff pressure will vary periodically in synchrony with the cyclic expansion and contraction of the brachial artery. The values of systolic and diastolic pressure are computed from the raw data, using an algorithm.



It evaluates the oscillations of the arteries. Those oscillations have a very typical curve. The oscillations occur when the blood flow first is interrupted and than starts flowing again. They become stronger, than diminish until they disappear when the blood starts flowing normally.
Both the systolic and diastolic value is calculated with the help of an algorithm. The calculated values are than visualized on the display.

Pulse Rate Analysis

Pulse rate is the rate at which the heart beats. The pulse is usually called heart rate, which is the number of times the heart beats each minute.

As the heart pumps blood through your body, you can feel a pulsing in some of the blood vessels close to the skin's surface, such as in your wrist, neck, or upper arm.

When the heart muscle contracts, blood is ejected from the ventricles and a pressure pulse is transmitted through the circulatory system. This pressure pulse displaces the vessel wall when traveling through the vessels. The pulse wave travels at 5 to 15m/s depending on the size and rigidity of the arterial walls. The velocity is high for large and more rigid artery walls. The velocity is 10 to 15 times faster than blood flow and is relatively independent of it. The pulse can be felt by placing the finger tip over the radial artery in the wrist or wherever an artery is just below the skin. The pulse pressure, timing and waveform are indicators for blood pressure and flow. Instruments used to detect the arterial pulse and pulse pressure waveforms in the extremities are called plethysmographs.

Three methods to measure pulse rate are

1. Electrical impedance method
2. Strain gauge method or microphone
3. Photoelectric method/Optical method

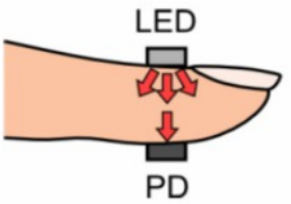
1. Electrical impedance method: The impedance change occurring between two electrodes attached to the body, due to change in the blood volume between them is measured. This is done by applying an alternating current (10 - 100 kHz) between the electrodes. The alternating current is used instead of dc in order to prevent polarization of the electrodes. The change in impedance (0.1 ohm) is very small compared to the total impedance (several hundred ohms).

2. Mechanical Method: A strain gauge is connected to a rubber band placed around a limb or a finger. The resistance of the strain gauge changes when the band expands due to change in blood volume. A semiconductor strain gauge can also be used. In another technique, a sensitive crystal microphone is placed on the skin's surface to pick up the pulsation.

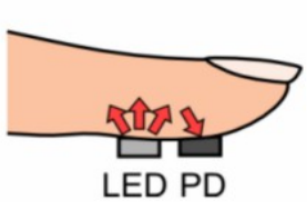
3. Optical method (Photoelectric Plethysmography): The most commonly used method to measure the blood volume changes is by photoelectric method. Two methods are common: Reflectance method and transmittance method.

a) Transmittance method: A LED and a photoresistor connected as part of a voltage divider circuit are mounted in an enclosure that fits over the tip of the patient's finger. Light is transmitted through the finger tip and falls on the photoresistor. With each contraction of the heart, the blood is forced into the finger and the amount of blood in the finger increases. Hence

the light transmitted by the finger reduces and hence the resistance of the photoresistor increases. Thus the voltage drop across the photoresistor varies according to the amount of blood in the finger. This voltage displayed on an oscilloscope or recorded on a strip-chart recorder, closely follows the wave shape of the pressure pulse.



b) Reflectance method: The photoresistor is placed adjacent to an LED. Part of the light rays emitted by the LED is reflected and scattered from the skin and tissues, based on the amount of blood in the finger, and falls on the photoresistor. Hence the voltage drop across the photoresistor varies according to the amount of blood in the finger. Change in voltage is proportional to pulse rate.



The LED's used are Ga-As(Gallium Arsenide) IR emitting diode.

Advantages of measuring pulse:

1. The monitoring of pulse is more useful and dependable that monitoring the heart rate derived from ECG in the case of a heart block because it immediately indicates the cessation of blood circulation in the limb terminals.
2. Photoelectric transducer is much easier to apply than three ECG electrodes.
3. The amplitude of plethysmographic signal is large compared to ECG signal and therefore gives better signal to noise ratio.

Disadvantages: However, the technique is severely subject to motion artifacts.