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Department of Physiology  
Physiology Lab

# Assessment of Vital Signs: Measurement of Arterial Blood Pressure

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# Outlines



- Objectives and Background



- Hypertension Vs Hypotension



- Methods of Measuring Blood Pressure



- Procedure



- Korotkoff's sounds.

# Objectives

**This lab aims to :**

**1**

Train the student on the correct way to measure the arterial blood pressure in human beings.

**2**

Discuss the importance of the blood pressure in assessing the health status of the individual.

**3**

Explain the factors that may affect blood pressure and its accuracy using different methods.

# Vital Signs

- “**Temperature**, **Pulse**, **Respiration**, and **Blood Pressure** are the **Vital Signs**”. They are also called **“Cardinal Signs”**.

- They reflect the body’s physiological status and provide useful information about the general health and condition of the individual.

- The frequency of vital signs assessment depends upon the person’s condition. The more critical the patient’s condition is, the more often these signs are needed to be taken and evaluated.

# Assessment of Vital Signs

- **Assessment of vital signs** is one of the most important milestones of general examination. They are “vital” because they give a rapid and good general impression about the patient’s health status (*When these values are not zero, they indicate that a person is alive* ).
- *Vital signs* are useful in detecting or monitoring medical problems. They can be measured in a medical setting, at home, or at the site of a medical emergency.
- **The main vital signs are:**
  - ✓ **Blood Pressure ( Today Lab)**
  - ✓ Body Temperature
  - ✓ Pulse Rate
  - ✓ Rate of Breathing ( Respiration Rate)
- Recently, many studies have designated the pain as a fifth vital sign.

# Blood Pressure

## Introduction

- *Blood pressure* is one of the essential parameters in cardiovascular physiology. It is considered as one of the most important vital signs during patient assessment because it can provide clinicians with a fast indication of cardiovascular performance.

## Definition

- *Blood pressure refers to the force exerted by circulating blood on the walls of blood vessels*, and constitutes one of the principal vital signs. The pressure of the circulating blood decreases as blood moves forward through arteries, arterioles, capillaries, and veins.

## Arterial Blood Pressure

- The term *blood pressure generally refers to arterial pressure (AP)*, due to the fact, that they are the vessels where the pressure is measured.

# Blood Pressure

## Blood Pressure

- **Blood pressure** is usually recorded as :**Systolic pressure/Diastolic pressure** .

## Systolic Pressure

- **Systolic pressure** is the peak pressure, which occurs near the beginning of the cardiac cycle when the ventricles are contracting . Normal range is 100-140 mmHg .

## Diastolic Pressure

- **Diastolic pressure** is the minimum pressure in arteries, which occurs near the end of the cardiac cycle when the ventricles are filled with blood (heart's relaxation) . Normal range is 60-90 mmHg.

## Pulse Pressure

- **Pulse pressure** is the difference between systolic pressure and diastolic pressure . Normal range is 30-60 mmHg .

## MAP

- **Mean arterial pressure (MAP)** is the average of arterial pressure with respect to time (Mean arterial pressure= diastolic pressure+1/3 pulse pressure).

# Blood Pressure

*In the USA, the optimal blood pressure (gold standard) targets are:*

*Systolic: less than 120 mmHg*

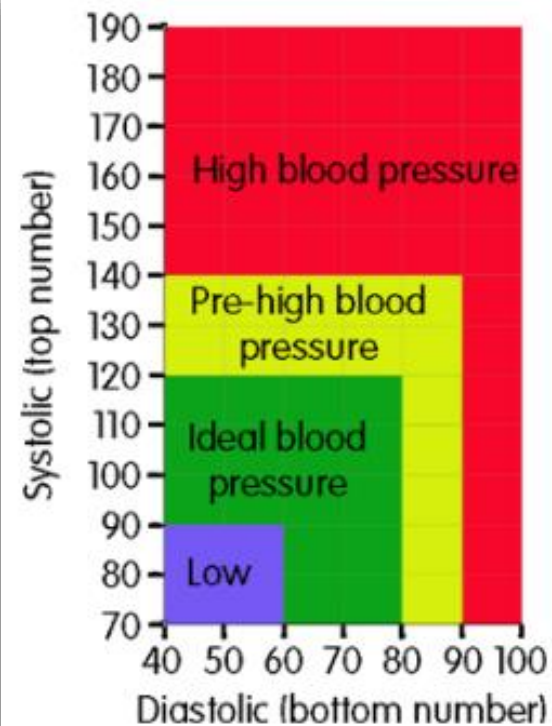
*Diastolic: less than 80 mmHg*

*Levels above 120 mmHg but below 140 mmHg in systolic pressure, or above 80 but below 90 mmHg in diastolic pressure are referred to “**prehypertensive**” and often progress to frankly hypertensive level.*

*In the UK, students continue to be taught that the:*

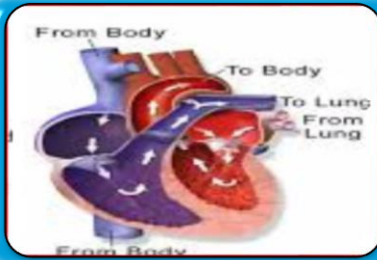
*Normal range is :*

*100-140 mmHg for **systolic pressure** &  
60-90 mmHg for **diastolic pressure**.*





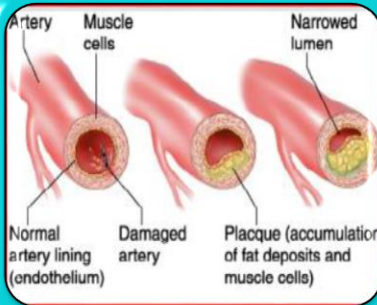
# Determinants of Blood Pressure



## Pumping Action of the Heart

*Weak: Lower cardiac output → BP decreases*

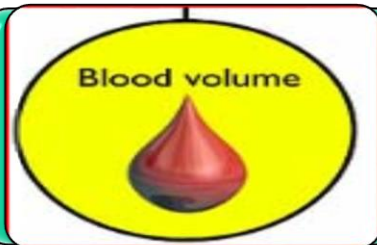
*Strong: Higher cardiac output → BP increases*



## Peripheral Vascular Resistance

*Increased vasoconstriction → increases peripheral resistance → BP increases (e.g. smoking)*

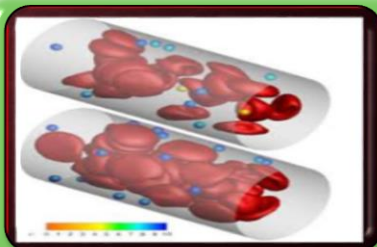
*Decreased vasoconstriction → decreases peripheral resistance → BP decreases*



## Blood Volume

*Decreased → BP decreases ( e.g. hemorrhage)*

*Increased → BP increases ( e.g. rapid intravenous infusion)*



## Blood Viscosity

*High → increases BP*

*Low → decreases BP*

**Remember that :** *Arterial blood pressure = cardiac output × peripheral resistance*

# Factors Affecting Blood Pressure

## Age

- *BP increases with age* due to the structural changes in the arteries.

## Stress

- *Stimulation of the sympathetic nervous system* increases cardiac output & vasoconstriction of the arterioles → *BP increases*.

## Gender

- *Females usually have lower BP than male* due to hormonal variations. After menopause, women have higher BP than before.

## Diurnal Variations

- BP is usually lowest early in the morning (metabolic rate is lowest) then rises throughout the day and peaks in the late afternoon or early evening.

# Factors Affecting Blood Pressure

## Exercise

- Physical activity increases the cardiac output  $\rightarrow \uparrow$  BP

## Obesity

- Childhood and adult obesity predispose to hypertension.

## Medications

- Many medications may increase or decrease BP.

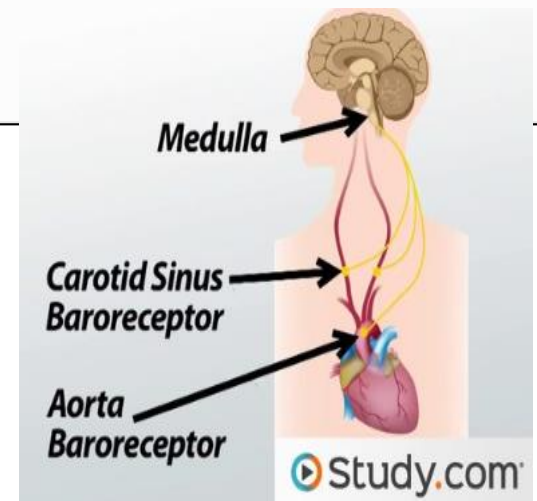
## Disease process

- Any condition affecting the cardiac output, blood volume, blood viscosity, and/or compliance of the arteries has a direct effect on the BP.

# Regulation of Blood Pressure

- *Blood pressure monitoring is performed by baroreceptors.* The aorta and the carotid sinus contain important baroreceptors which transmit their data to the *cardio-regulatory center of the medulla oblongata.*

- *If blood pressure increases,* it will be detected by the baroreceptors. This information is then sent via nerves to the cardio regulatory center within the medulla, which responds by initiating mechanisms that decrease the blood pressure to a normal level.



# Regulation of Blood Pressure

- *To lower blood pressure*, there will be a decrease of sympathetic input and an increase in parasympathetic input to the heart. This will lead to a decrease in the heart rate and stroke volume, which decreases the cardiac output and decreases blood pressure. Additionally, the cardio regulatory center of the medulla will also decrease sympathetic input to the blood vessels → vasodilation → decreases total peripheral resistance → decreases BP .

- **The opposite happens when the baroreceptors detect a drop in blood pressure.** *To raise blood pressure* , there will be.....  
.....  
.....

# High Blood Pressure (aka Hypertension)

- *A **blood pressure** that is persistently above normal*, (Medical condition in which constricted arterial blood vessels increase the resistance to blood flow causing an increase in BP).

- The most common disease in primary care , with estimated about *1 billion people affected worldwide.*

- ***Systolic pressure*** is consistently  $> 140 \text{ mmHg}$
- ***Diastolic pressure*** is consistently  $> 90 \text{ mmHg}$

- Numerous interventions including both lifestyle modification and pharmacological treatment have been shown in clinical trials to produce major reduction in BP.

# Types and Stages of Hypertension

## Types

### *Primary “essential” hypertension:*

1. Most cases the causes of this type is **unknown**.
2. Majority of people with this type feel no different from those who have normal BP.

### *Secondary hypertension*

This is when high BP is as a result of other medical problems (like kidney or liver problem) or medication.

## Stages

<u>BP Classification</u>	<u>Systolic BP</u> (mmHg)	and	<u>Diastolic BP</u> (mmHg)
Normal	<120		<80
Prehypertension	120-139	or	80-89
Stage 1	140-159	or	90-99
Stage 2	≥ 160	or	≥ 100
Systolic HTN	> 160		<90

# Symptoms of Hypertension

HIGH BLOOD PRESSURE IS A



**SILENT  
KILLER**

because there are no  
obvious signs or symptoms

## The Silent Killer

- Hypertension is sometimes referred to as a “*Silent Killer*” . Why?

Symptoms of extremely high blood pressure include the following:

- Severe headache
- Fatigue
- Vision problem
- Chest pain
- Difficulty in breathing
- Irregular heartbeat
- Blood in urine
- Pounding in chest, neck, or ears



# Causes and Complications of Hypertension

## Causes of Hypertension

- The following factors may increase one's risk for high blood pressure:
  - Smoking
  - Overweight or obesity
  - Lack of physical activity
  - Too much salt consumption
  - Too much alcohol consumption
  - Stress
  - Older age
  - Genetics
  - Family history of high blood pressure
  - Chronic kidney disease
  - Sleep apnea

## Complications

- Cardiovascular disease
- Atherosclerosis- “ Hardening of the arteries”
- Stroke or heart attack
- Coronary artery disease
- Angina
- Kidney damage
- Vision loss

# Low Blood Pressure (aka Hypotension)

- A blood pressure that is below the normal.
- *Systolic pressure* is Consistently less than 90 *mmHg*
- *Diastolic pressure* is consistently less than 60 *mmHg*

## Types of hypotension

- ***Orthostatic Hypotension ( postural hypotension)*** : Sudden drops in BP most commonly occur in someone who's rising from a lying down or sitting position to standing.
- ***Neurally Mediated Hypotension*** : low BP can occur when someone stands for a long period of time
- ***Severe Hypotension:*** leads to a life-threatening condition called shock.

# Symptoms and Causes of Hypotension

## Symptoms of Hypotension

- Dizziness or lightheadedness
- Fainting (syncope)
- Blurred vision
- Nausea
- Fatigue
- Lack of concentration
- Cold, clammy skin
- Pale skin

## Causes of Hypotension

- Dehydration
- Blood loss
- Heart problems
- Pregnancy
- Poor nutrition
- Severe burns
- Certain medications

# Methods of Measuring Blood Pressure

➤ *Methods of measuring blood pressure are classified into :*

✓ **Direct method (invasive)**

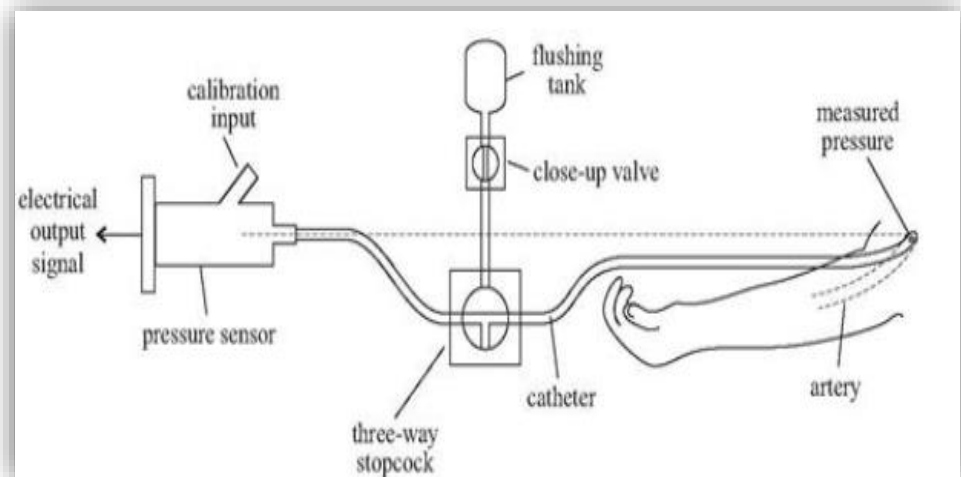
✓ Indirect method (noninvasive)

➤ **Direct Method (Invasive):**

- ❖ Not used in clinical practice. It is a very **reliable** technique for continuously measuring arterial pressure, consists of inserting a saline filled catheter through the patient's vascular system to the point at which it is desired to perform the measurements. The catheter is connected to an electronic pressure transducer, which measures the pressure in the artery (usually radial, femoral, dorsalis pedis or brachial). This is usually done by an anaesthesiologist or surgeon in a hospital.
- ❖ It is employed in humans (e.g, shock) , veterinary intensive care medicine, anesthesiology, and for research purpose.

# Methods of Measuring Blood Pressure

- ❖ Since these techniques involve making an incision through the patient's skin and inserting the catheter into a blood vessel, as a consequence, they entail **pain** and also some problems, like possibility of **infection, blood clots and other risks**.
- ❖ The advantage of this method is that pressure is constantly monitored beat-by-beat, and a waveform can be displayed. *What is also remarkable from this method, is that they provide the most accurate arterial pressure reading from patients.*



**Direct BP measurement set-up with external pressure sensor**

# Methods of Measuring Blood Pressure

## Indirect Methods (Noninvasive)

**Palpatory Method**

**Auscultatory Method**

**Oscillometric Method**



# Sphygmomanometer and Stethoscope

## Types of Sphygmomanometer

Digital Sphygmomanometer



Mercury Sphygmomanometer



Aneroid Sphygmomanometer



## Stethoscope

Earpieces



Bell (with hole)

Diaphragm

nursing-skills-guide

Mercury Manometer

Box case

Mercury

Inflation bulb

BP Cuff

valve

Lock








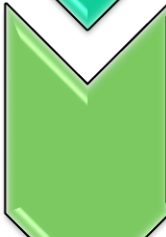

# Auscultatory and Palpatory Methods

- ✓ The auscultatory and palpatory methods use stethoscope and sphygmomanometer. This consists of an inflatable cuff placed around the upper arm at roughly the same vertical height as the heart. The cuff is attached to mercury or aneroid manometer.
- ✓ The mercury manometer considered to be the “*gold standard*” for BP measurement, measures the height of the mercury column gives an absolute result without any need for a calibration and consequently not subjects to error and drift of calibration that affect other methods.
- ✓ The use of mercury manometer is often required in clinical trials and for clinical measurements of hypertension in high risk patients.




# Auscultatory and Palpatory Methods

## Before measuring BP:

- 
- Check the proper size of the air bag within the cuff which should extend for at least  $\frac{2}{3}$  of the circumference of the arm.
- 
- Clothes must be removed from the arm and the arm supported at the heart level with the level of sphygmomanometer.
- 
- Person lying or sitting relaxed.
- 
- Expose the upper arm (left or right, some research have shown that BP measured on left arm is higher than the right arm by 5mmHg).
- 
- Wrap the cuff well around the arm (2.5 cm above the cubital fossa), neither tight nor loose.

# Procedure of Palpatory Method


The cuff of the sphygmomanometer is wrapped firmly around the right arm above the elbow. The lower arm should be resting on a tabletop or bench.



Palpate the radial pulse with the fingers of the left hand.



Close the valve on the inflating bulb, then inflate the cuff slowly (10 mmHg/sec) by pumping the inflating bulb until the radial pulse is no longer felt. The cuff is inflated further until the pressure is about 30 mmHg higher.



Open the valve slightly by turning it in the counterclockwise direction, allowing the pressure to drop slowly by about 5 mmHg/sec.



while the pressure is released the artery is palpated until the pulse is felt again. That denotes systolic pressure.

# Palpatory Method

Palpatory method is *only used to measure systolic pressure.*

The systolic pressure reads *2-5 mmHg lower than that measured by auscultatory method.*

This method helps one to avoid a lower systolic reading by auscultatory method if there is an *auscultatory gap.* It also minimizes the discomfort of over inflating the bladder of the cuff.




Source – [www.gehealthcare.com](http://www.gehealthcare.com)


# Procedure of Auscultatory Method

*It is the most accurate method that measures both systolic pressure and diastolic pressure .*

After the cuff is placed snugly over the arm, put the diaphragm of the stethoscope at the position of brachial artery, just below the lower edge of the cuff ( not underneath the cuff).

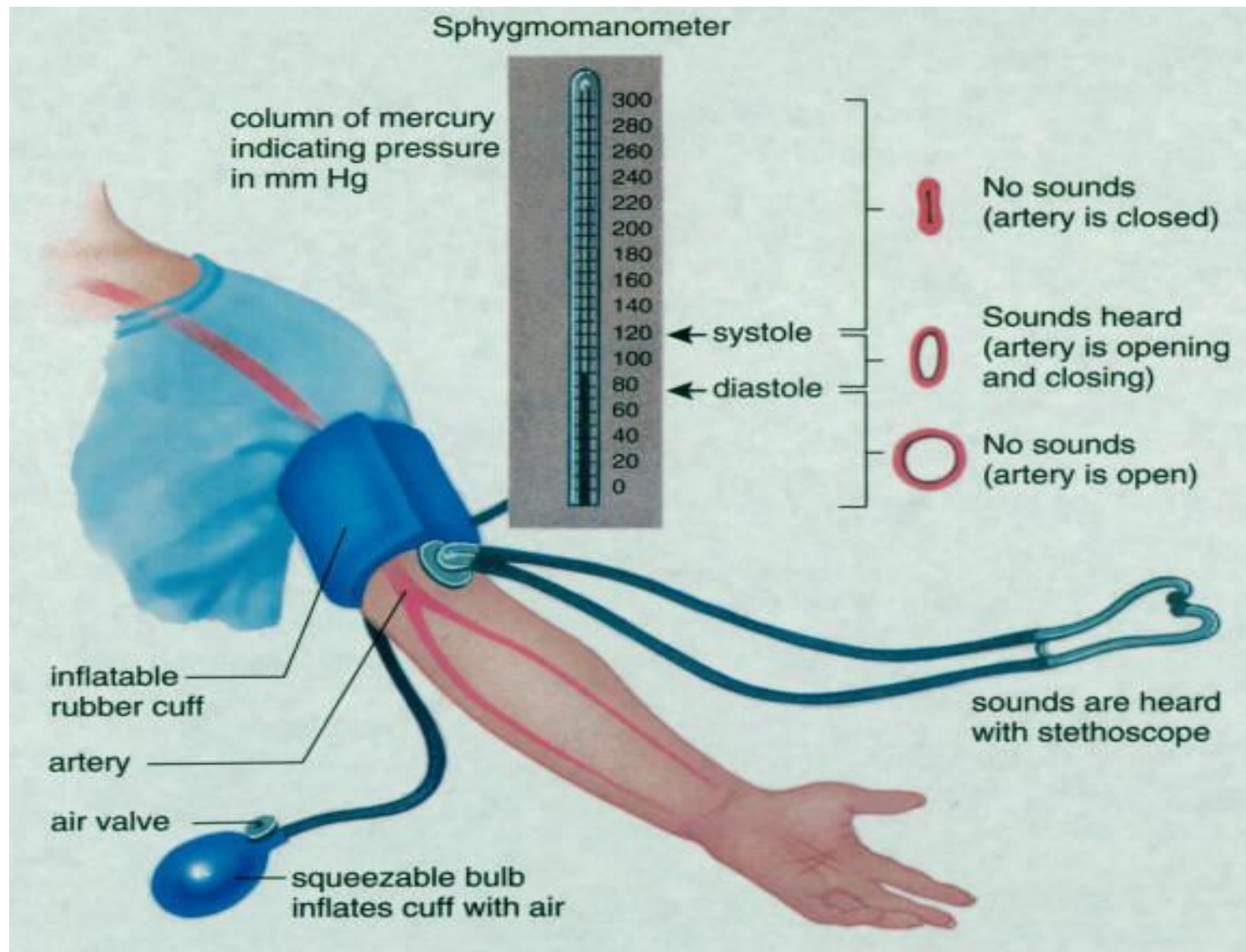


Raise the pressure to above the expected systolic pressure so that the brachial artery is occluded due to compression.



Lower the cuff pressure slowly . By doing this series of sounds are heard through the stethoscope . These sounds are called **Korotkoff's sounds**.

# Auscultatory Method



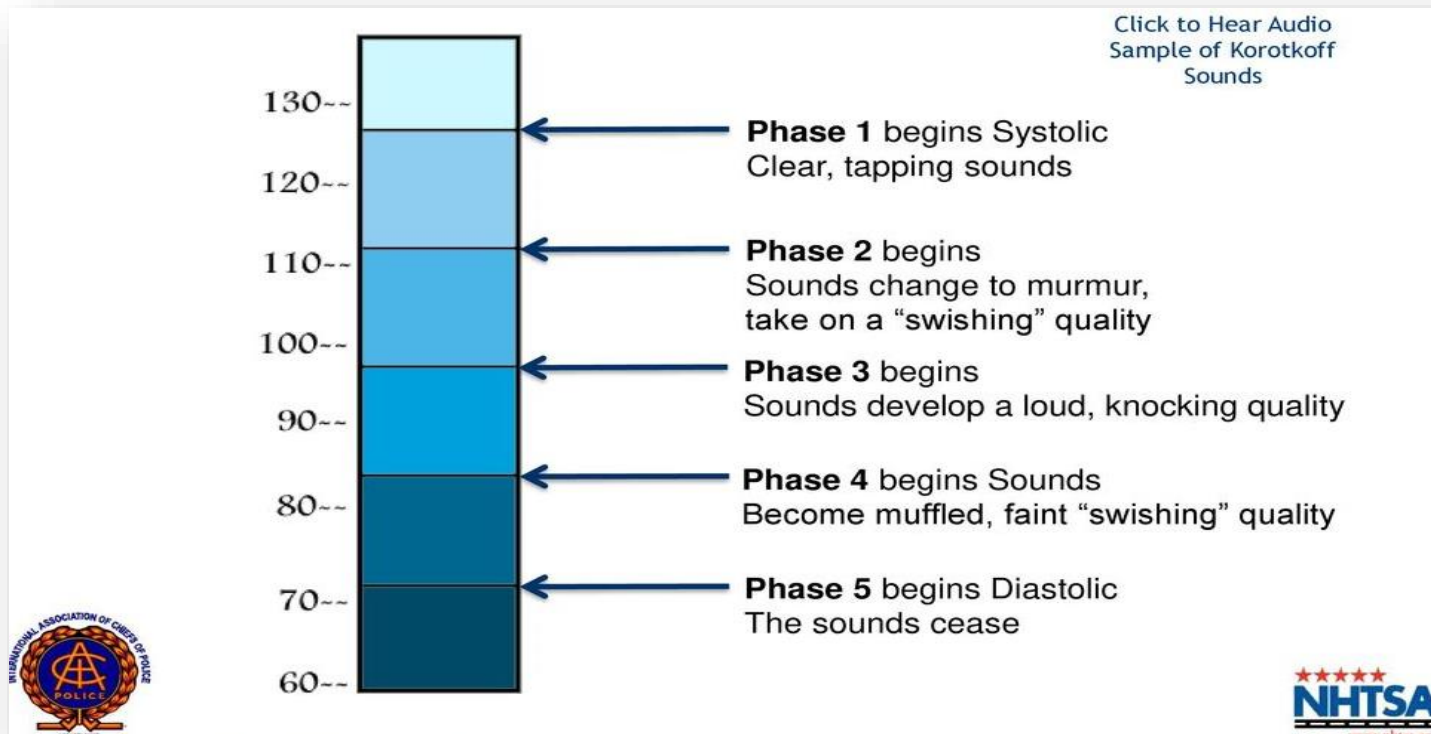
# Korotkoff's Sounds

The following phases of Korotkoff's sounds will be heard by the stethoscope:

- **Phase I:** If the pressure is above the systolic, no sound is heard. When systolic pressure is reached, a clear tapping sound is heard (systolic pressure).
- **Phase II:** when we lower the pressure, the sound becomes softer.
- **Phase III:** as the pressure is lowered more, the sound becomes louder.
- **Phase IV:** The sound becomes muffled.
- **Phase V:** Disappearance of the sound ( represents diastolic pressure).
- Try to hear the Korotkoff's sound using the bell of the stethoscope instead of the diaphragm . What do you think ?






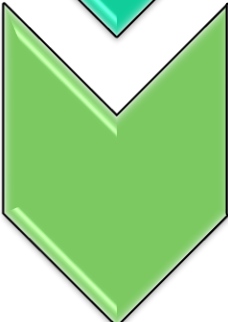
# Korotkoff's Sounds



## Notes:

- ✓ In some conditions (adults after exercise, in children, and pregnant women), Korotkoff sound does not disappear and persists as muffled sound (phase IV). In such cases phase IV is used as diastolic pressure.
- ✓ The exact cause of K. sounds is still debated, but it is thought to be caused by blood jetting through the partly occluded vessels. The jet causes turbulence in the open vessel beyond the cuff and this sets up the vibrations heard by the stethoscope.

# Oscillometric Method

- 
- The equipment is functionally similar to that of the auscultatory method, but with an electronic pressure sensor fitted in to detect blood flow, instead of using the stethoscope and the expert's ear.
- 
- Oscillometric method operates by sensing the magnitude of oscillations caused by the blood as it begins to flow again into the limb.
- 
- It uses an algorithm to compute systolic pressure and diastolic pressure. Useful for determining accurate estimates of mean arterial pressure.
- 
- Sometimes used in the long-term measurement and in general practice. It requires less skill than the auscultatory technique, and may be suitable for use by untrained staff and for automated patient home monitoring.



# Oscillometric Method

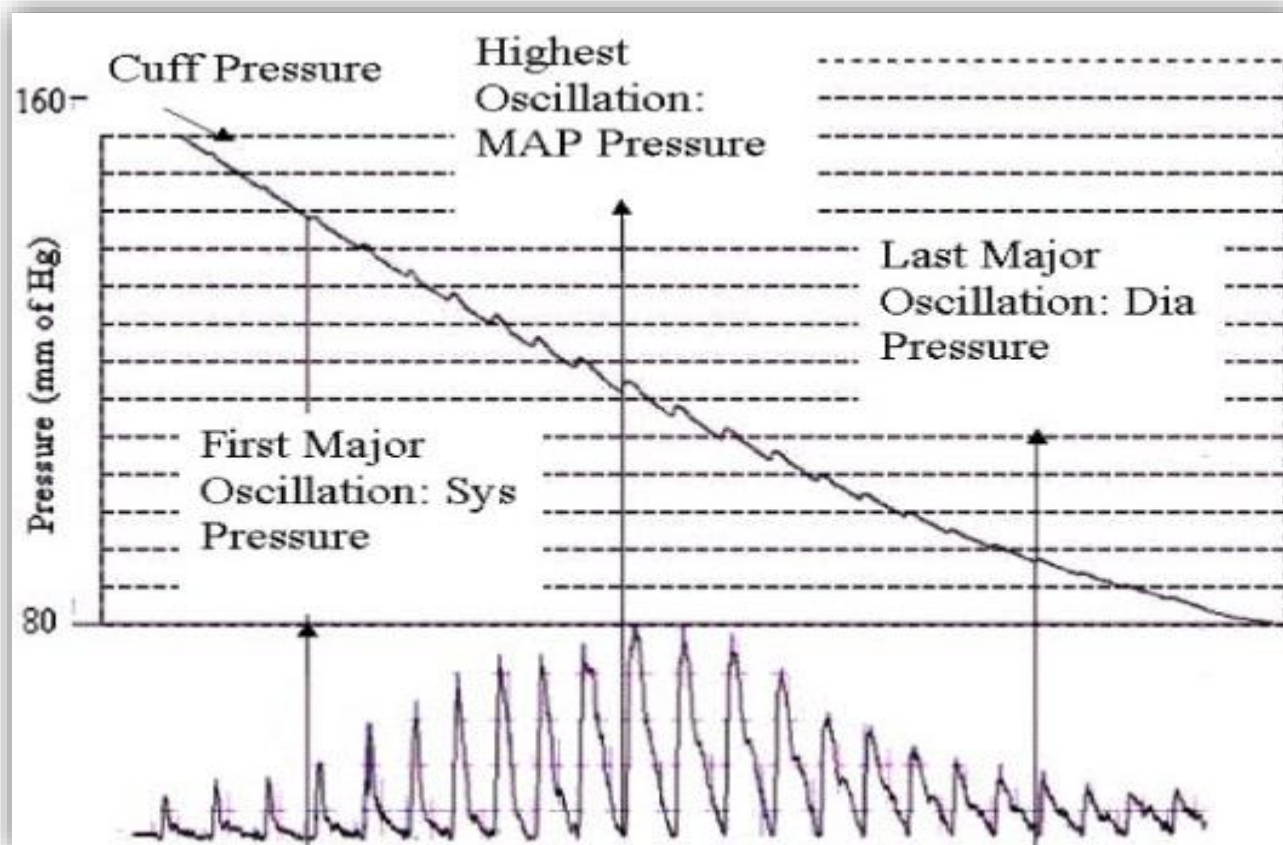


## Procedure:

- The cuff is inflated and released by an electrically operated pump and valve, which may be fitted on the upper arm.
- First of all, like with auscultatory method, the cuff is inflated to a pressure initially in excess of the systolic arterial pressure, and then reduces to below diastolic pressure over 30 seconds.
- When blood flow is nil (cuff pressure exceeding systolic pressure) or unimpeded (cuff pressure below diastolic pressure), cuff pressure will be essentially constant. When blood flow is present, but restricted, the cuff pressure, which is monitored by the pressure sensor, will vary periodically in synchrony with the cyclic expansion and contraction of the brachial artery, that means the cuff pressure will oscillate.

# Oscillometric Method

- Oscillometric monitors may produce inaccurate readings in patients with heart and circulation problems, that include arterial sclerosis, arrhythmia and preeclampsia.



Oscillometric Method

# Blood Pressure

## Important Notes:

The cuff size must be correct. Undersized cuff may result in a too high pressure / Oversized cuff may result in a too low pressure.

Up to 25% of patients diagnosed with hypertension do not actually suffer from it but rather from white coat hypertension. Thus, well-performed and accurate home monitoring can prevent unnecessary anxiety as well as costly and potentially dangerous therapy in many millions of people worldwide.

# Take Home Assignments

## Assignment #1

- Why does reducing how much salt you eat help prevent high blood pressure?

## Assignment #2

- Is there a difference in blood pressure between upper and lower extremities? Explain your answer.

## Assignment #3

- Does blood pressure change with the body Position (standing, sitting, and lying)? Explain your answer. Which is the most reliable position for the measurement of the blood pressure?

## Assignment #4

- Data from China and Italy (countries hit early by the corona virus , COVID-19) show higher risk of COVID-19 infections and complications in people with high blood pressure. Can you explain the link?

# Am I high or low?

## HIGH PRESSURE

Pressure headache (global, but especially in back of head)

Pressure behind my eyes

Blurry vision

Stiff neck

Gets much worse when flat



These are just @jenbrea's symptoms. Please check out official symptom lists and consult with your doctor when evaluating your own case!

People can bounce back and forth between high and low pressure. Abnormal pressure can have many causes.

## LOW PRESSURE

Frontal headache

Weird spots in my vision

Nausea

Feel like I am going to "pass out" (pre-syncope)

Back pain

Improves or resolves when flat

<https://twitter.com/jenbrea/status/1176591717895532544>



*These simple tips to reduce stress can help you to lower your high BP*

