Physiology
OF THE CARDIOVASCULAR SYSTEM

- Very important
- Extra information
- Terms

Electrocardiogram

Objectives :

1. ECG paper.

2. ECG leads:
- Limb leads.
- Chest leads.

3. Interpretation of the ECG.

4. Cardiac axis.

5. Heart rhythm.

6. Heart rate.

ECG

DEFINITION OF ECG :

ECG records the electrical changes (depolarization and repolarization) that take place in the heart/per cycle

⇩

These changes can be detected by electrodes attached to the surface of the body

⇩

Because the body fluids are good conductors of electricity, fluctuations (depolarization and repolarization) in electrical potential during a cardiac cycle can be recorded extracellularly by placing recording electrodes on the surface of the human body. These electrical potentials represent the algebraic sum of the action potentials of myocardial fibers and when these are recorded by placing electrodes on the skin of human body, it is called electrocardiography or ECG. Hence we can define the ECG as: **"the algebraic sum of all the electrical potentials of the heart recorded from the body surface"**

ECG

Before Recording :

- The Subject should be supine and relaxed . (any movement will be recorded)
- The Temperature of the room should be neither too hot nor too cold , it should be comfortable (neutral)
- The Temperature of the room should be neither too hot nor too cold , it should be comfortable (neutral)

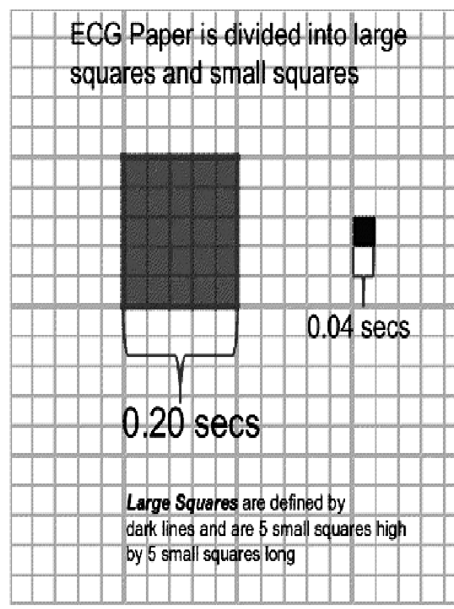
We should clean the electrodes site with alcohol swab and put gel on the electrode .why ? Because The outside layer of skin you see everyday in the mirror is really made up of dead skin cells. These skin cells act as a good resistor, meaning that it makes detecting electrical activity difficult for your ECG electrodes . So we put ECG Electrode Conductive Gel

The ECG Paper :

The ECG is recorded on a graphic paper with standard-sized squares .

The horizontal axis: time measured in seconds

One small square (1mm)	0.04 seconds
One large square	0.20 seconds
5 large squares	1 second



The vertical axis: changes of voltage

- 10mm = 1cm = 1millivolt.

- A signal of 1(mV) should move the stylus vertically 1 cm (2 large squares).

The standard paper speed is 25mm/sec.

How many large squares in one second ? (0.20× 5) = 5 large squares
How many large squares in 1 minute ? (5×60seconds)= 300
How many small squares in 1 minute ? (300×5) = 1500 small squares
يفضل دائماً نحسب بالمربعات الصغيرة لانها اكثر دقة

The 12 standard ECG leads

- A **lead** is formed by a **pair of electrodes** joined together to record the potential difference between the two electrodes .
- Each lead looks at heart from a different angle so as to locate an abnormality in the heart that can be detected by ECG.

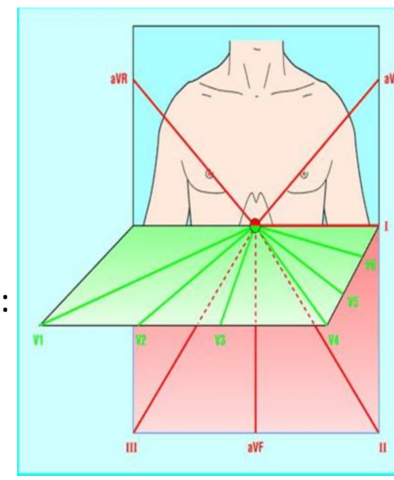
- Out of **12 leads**, 6 are **limb** leads and 6 are **chest** leads.

Frontal Plane (6 limb leads)

Bipolar Leads : I , II , and III
Unipolar leads : leads: aVR, aVL, aVF

Transverse Plane :

Unipolar chest leads : V1 to V6



- Record the difference in potential between **2 limbs**.

- ECG was first recorded by placing electrodes on 3 places :

Right and Left arms and Left leg

(Recording +ve Ede) (-ve reference Ede)

- Depolarization moving towards a +ve Ede produces a +ve deflection.

- Depolarization moving in the opposite direction produces a –ve deflection.

Type of Lead	Limb Leads	Precordial or Chest Leads
Bipolar	I, II, III (standard limb leads)	-
Unipolar	aVR, aVL, aVF (augmented limb leads)	V_1-V_6

PHYSIOLOGY TEAM435

The 12 standard ECG leads

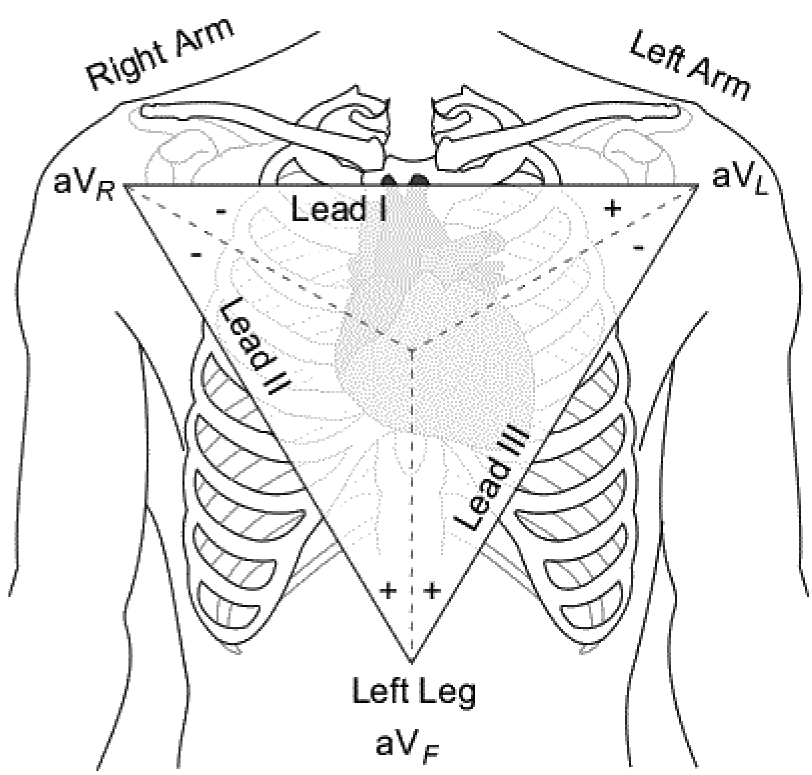
Lead I is a standard bipolar limb lead that records potential difference between right arm and left arm, with its positive electrode being on the left arm.

Lead II is a standard bipolar limb lead that records potential difference between right arm and left foot, with its positive electrode being on the left foot.

Lead III is a standard bipolar limb lead that records potential difference between left arm and left foot, with its positive electrode being on the left foot.

- The 3 leads arranged as a triangle are known as

Einthoven's triangle



The 12 standard ECG leads

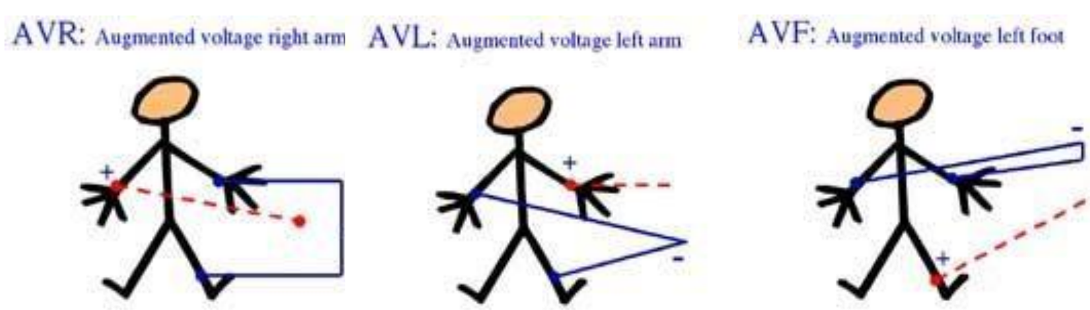
Augmented unipolar limb leads aVR, aVL, and aVF :

These are termed unipolar leads because there is a single positive electrode that is referenced against a combination of the other limb electrodes.

Are recordings between 1 limb and the other 2 limbs.

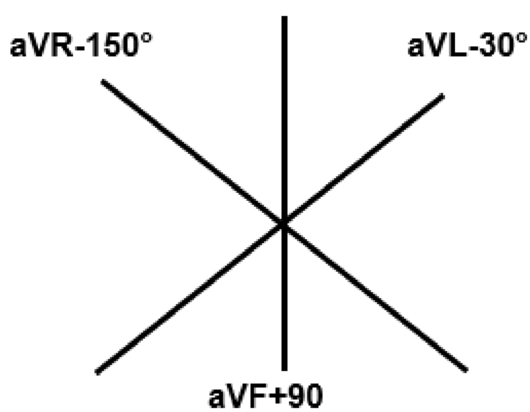
- **aVR** : augmented, Voltage, Right arm +ve
- **aVL** : augmented, Voltage, left arm as +ve.
- **aVF** : augmented, Voltage, left leg as +ve.

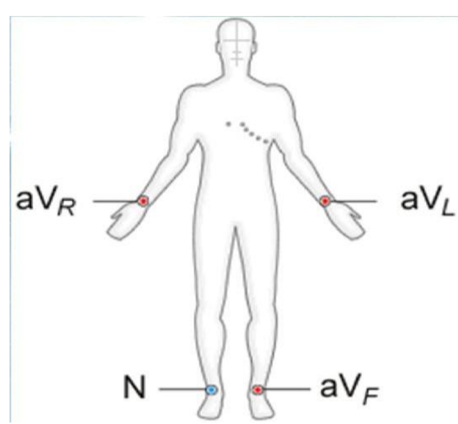
In practice, these are the same electrodes used for leads I, II and III. (The ECG machine does the actual switching and rearranging of the electrode designations).



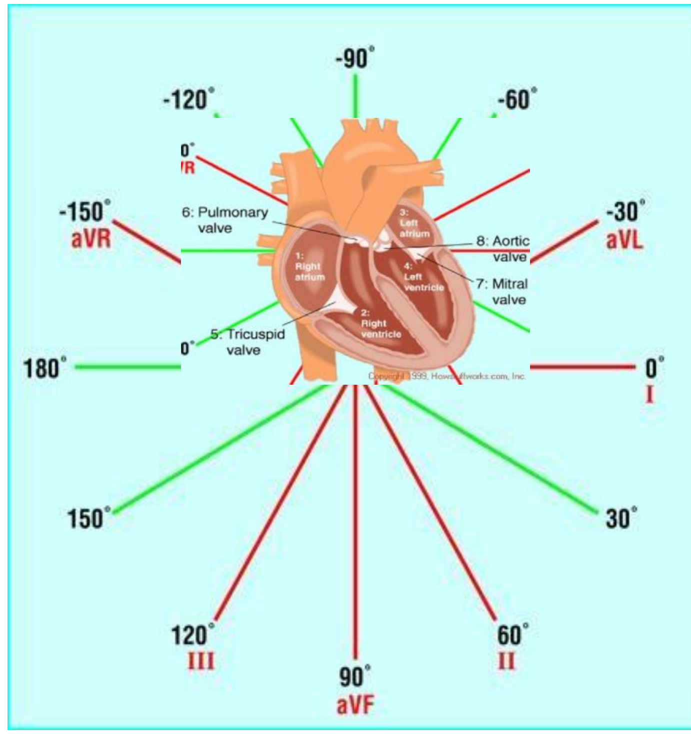
Leads aVR, aVL, aVF cross at angles and produce an intersection of 3 other lines.

Angles of 60° like for lead I, II, III.





For better understanding watch this video (Here)



Formation of hexaxial system :

Leads aVR, aVF, aVL divide the angles formed by lead I, II, III.

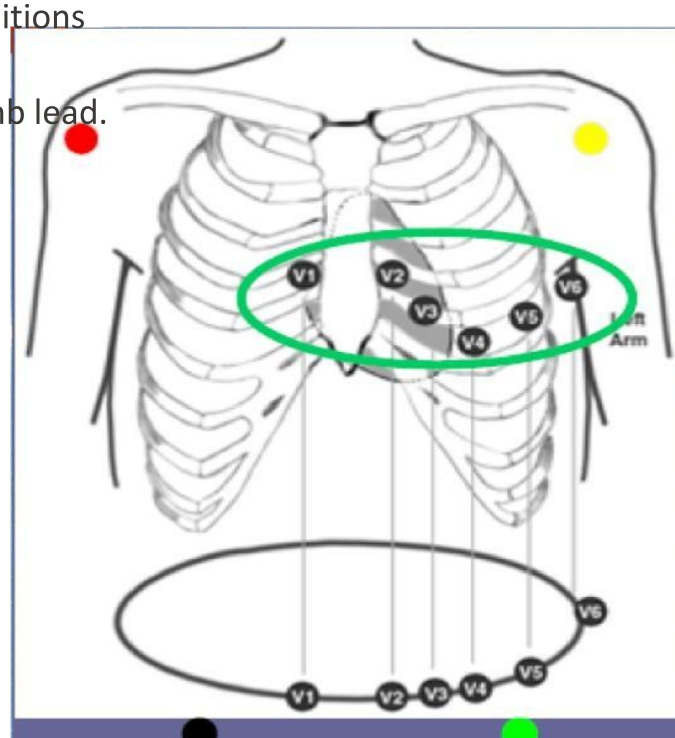
The leads cross precisely at 30°.

Watch this video (Here)

Chest leads :

6 standard chest leads depict electrical events in the **horizontal plane**

- One **+ve Ede** is placed on 6 different positions around the chest.
- The **reference –ve Ede** is a combined limb lead.

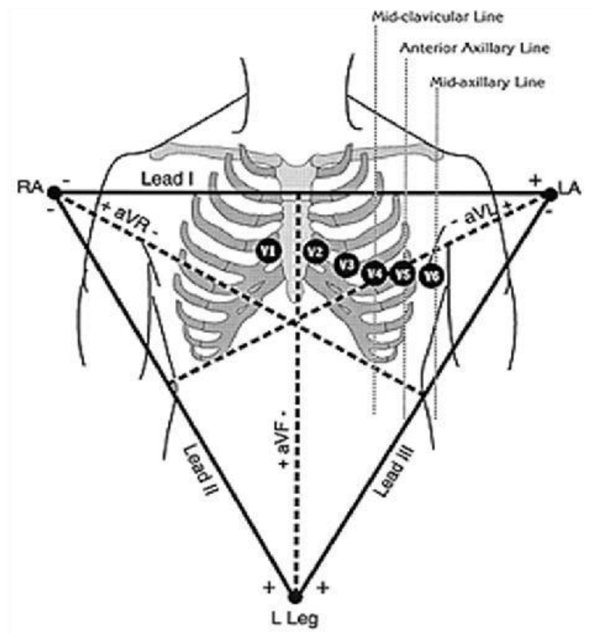


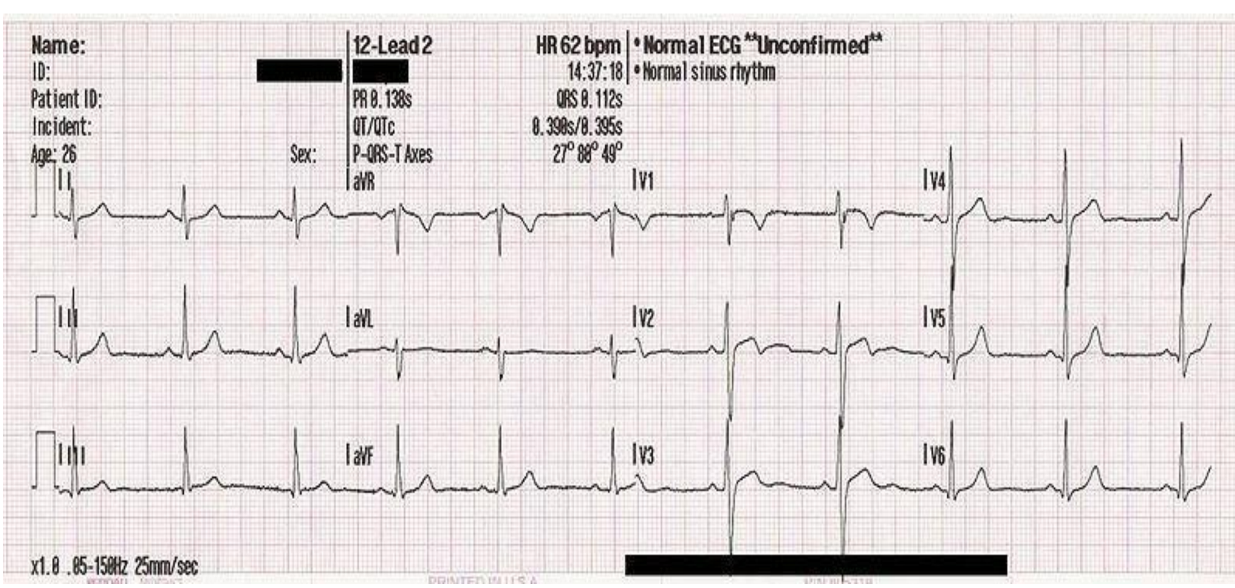
V1 : Right sternal border 4th ICS.
V2 : Left sternal border 4th ICS.
V3 : Halfway between leads V2 & V4.
V4 : Left mid- clavicular line, 5th ICS.
V5 : Anterior axillary line 5th ICS.
V6 : Mid axillary line 5th ICS.

The intercostal space (ICS) is the anatomic space between two ribs

- The standard 12-lead ECG :

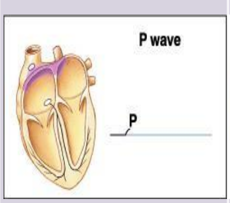
- How many electrodes?
- **10 electrodes**
-
- How many leads?
- **12 leads**

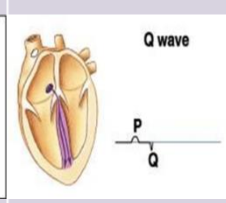


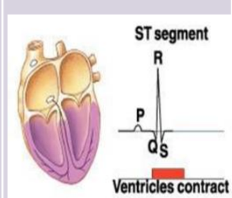


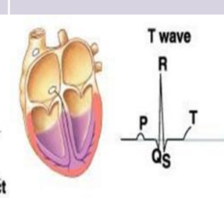
Interpretation of the normal ECG

Interpretation of the normal ECG	Atrial activation	Septal Activation (inter ventricular septum activation)	Ventricular depolarization	Ventricular repolarization	T WAVE
Definition	The impulse originates at SA node, spreads through the atria	The impulse spreads to the AV node, common bundle of His and R and L bundle branches then enters the IV septum.	The wave of depolarization spreads in the Purkinje fibers to all parts of the ventricles.	Ventricular repolarization represented by ST segment and T wave.	• ST segment: period between the end of QRS and the start of T wave. (earlier phase of repolarization of both ventricles extend from the end of QRS) • QT interval: from beginning of Q wave to end of T wave (ventricular dep and rep because it includes QRS complex, ST segment and T wave) < 0.43 sec. • ST interval: QT-QRS = 0.32 sec.
Cause	positive upward deflection	First negative deflection during PR segment	QRS		
wave	P wave	Q wave	The initial negative deflection is Q wave. The first positive deflection is R wave. The negative deflection after R wave is : S wave.	T wave	
Normal Range	Pw: <0.12 sec < 2.5 mm		QRS duration: < 0.10 sec.	0.1 -0.25	







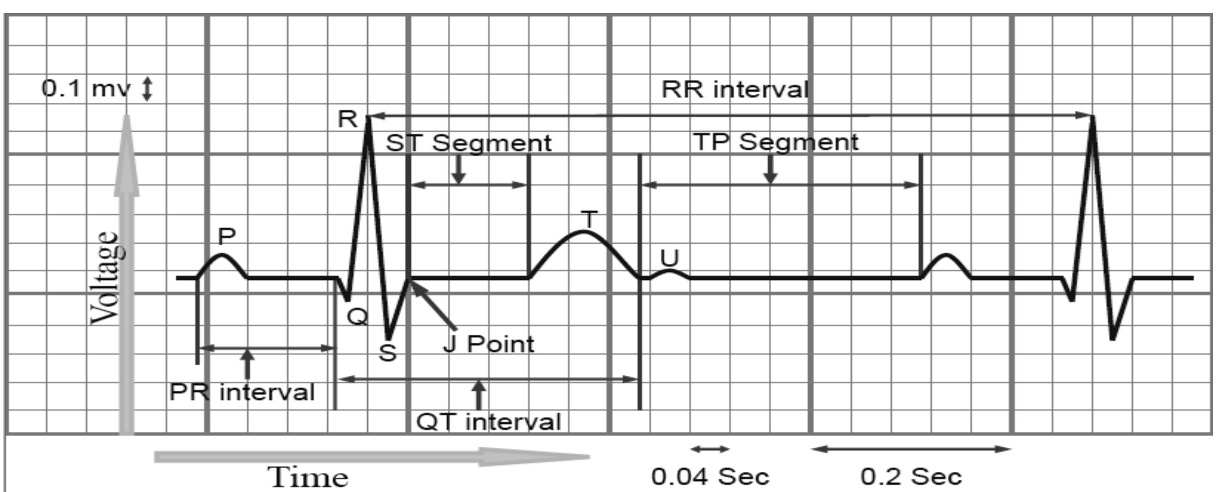


WAVES	
P WAVE	Represents atrial depolarization
QRS WAVE	Represents ventricular depolarization.
T WAVE	Represents ventricular repolarization.
U WAVE	Is sometimes present due to repolarization of hypertrophied papillary U wave muscles.(Physiological) and due to hypokalemia (pathological)

ECG Intervals				
Name of interval	What does the interval represent?	Normal range	Disease related to intervals	**Notes**
PR interval	From the "beginning of p-wave to the beginning of q-wave" (R-wave in case if Q-wave is absent).	0.12 – 0.20 seconds 3 to 5 small squares (less than 1 large square)	Prolonged PR interval more than 0.2 may be sign of first degree heart block.	PR shortens as heart rate increases
QRS duration	From the beginning of q-wave to the end of s-wave	0.08 – 0.1 Seconds (less than 3 small squares)	-	
QT interval	From the beginning of Q-wave to the end of t-wave	0.4 – 0.44 Seconds (10-11 small squares)	QT interval is short = hypercalcemia . Prolong the QT interval = hypocalcaemia	
ST interval	From the end of s-wave to the end of t-wave.	0.28 – 0.36 seconds	Elevated in myocardial infarction	

Calculation of The Intervals :

Remember the small squares are 0.04 so what we do is we count the number of small squares between the intervals and we multiply it by 0.04



- PR interval 0.12 – 0.20 sec
- QRS duration 0.08 – 0.10 sec

- QT interval 0.4 – 0.43 sec
- RR interval 0.6 – 1.0 sec

As an example :
Q-T interval = 8 small squares multiply by 0.04 = 0.32 sec
P-R interval = 3 small squares multiply by 0.04 = 0.12 sec
QRS duration = 2 small squares multiply by 0.04 = 0.08 sec

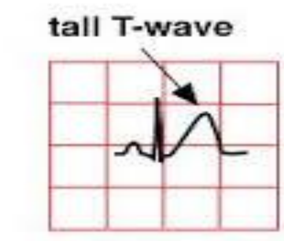
يوجد في السلايد التالي
طرقة عرض اخري لهذا
السلايد يمكنك الدراسة
باي واحدة تفضل

Examples of ECG abnormalities :

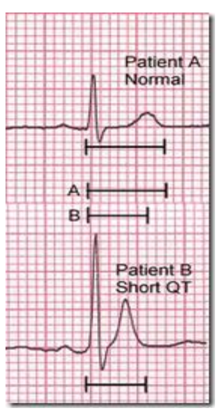
(The explanation of each abnormality and the photos are EXTRA)

1- Prominent U wave: hypokalaemia.

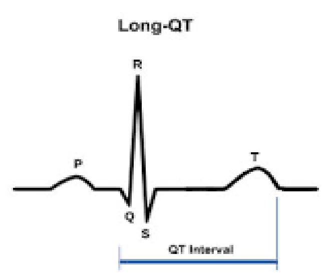
Note : The **U wave** is a **wave** on an electrocardiogram that is not always seen. It is typically small, and, by definition, follows the T **wave**



2- Tall Twave: hyperkalaemia



3- Short QT interval: hypercalcaemia.



4- Prolonged QT interval: hypocalcaemia.

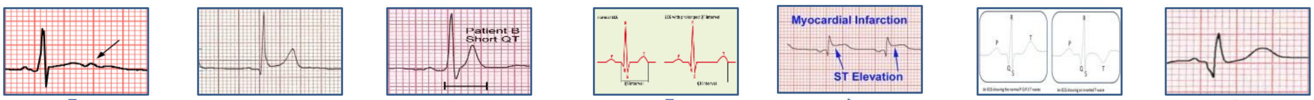
5-ST elevation, T inversion, large Q wave: myocardial infarction.

نفس الابنورماليتيز في السلايد السابق ولكن بطريقة عرض اخرى

Examples of ECG abnormalities

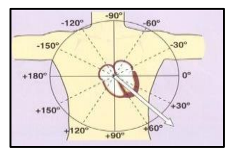
From these ECG waves we can indicate these problems

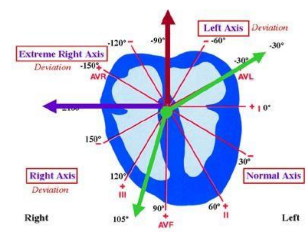
Prominent U wave	Tall T wave	Short QT interval	Prolonged QT interval	ST elevation	T inversion	Large Q wave



Hypokalemia	Hyperkalemia	Hypercalcemia	Hypocalcemia	Myocardial infraction

- **Cardiac axis:** the mean QRS vector is the preponderant direction of the potential during depolarization.
- The mean electrical axis of the ventricle is 59 °.



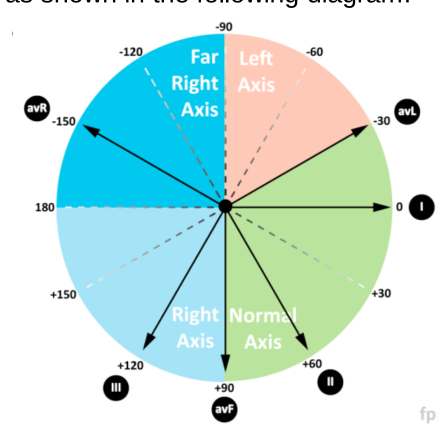


From -30° to +90°	From -30° to -90°	From +90° to ± 180°	From -90° to ±180°
Normal axis	Left axis deviation: • Normal in obese people. • LV hypertrophy. • L B B B	Right axis deviation: • Normal in tall thin people. • RV hypertrophy. • R B B B	Extreme right axis deviation

Determination of axis :

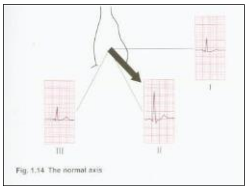
The electrical axis is the average direction of the current flow in the heart during a cardiac cycle.
The normal axis is between -30o to 90o.
In certain pathological conditions, it will deviate to the left (between -30o to -9oo) and is called left axis deviation (LAD) and in some other pathological condition, it will deviate to the right (90c to 1800) and it is called right axis deviation (RAD).
Beyond these values, it will be extreme or far right /left axis deviation, as shown in the following diagram:

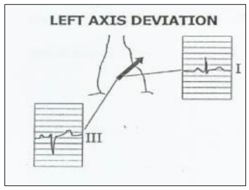
- We have to apply rule of thumb on the direction of R-wave in the Leads I and III/aVF of the ECG in order to determine the electrical axis of the heart.
- If the direction of R wave is upwards in both the leads I and III, then the electrical axis of the heart will be normal.
- If the direction of R-wave is upwards in the lead-1 and is downwards in the lead-III, then the electrical axis of the heart would be deviated to the left.
- If the direction of R-wave is downwards in the lead-1 and is upwards in the lead-III, then the electrical axis of the heart would be deviated to the right
- If the direction of R-wave is downwards in both the leads 1 and III, then the electrical axis of the heart will be deviated to the extreme left right.

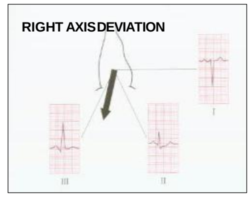


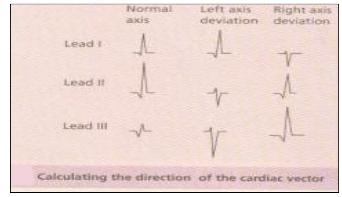
R-deflection	Lead-I	+	+	-	-
	Lead-III or aVF	+	-	+	-
Axis		normal	LAD	RAD	Extreme RAD or LAD

Inspection method:









Rhythm:

- ❖ The heart rhythm refers to the regulatory with which the heart beats.
- ❖ If the heart beats regularly, the rhythm is said to be normal.
- ❖ If the heart beats irregularly, it is called arrhythmia.
- ❖ Usually, **the heart beats faster during inspiration and slower during expiration**, showing a pattern of arrhythmia, but because it is purely physiological due to the different firing rate of SA node during inspiration and expiration, It is not considered pathological and it is called **Sinus Arrhythmia**.

- **Sinus rhythm: P wave before every QRS: Impulse from SAnode**
- **Sinus Regular : distance between R-R: constant**
- **Irregular : Unequal R-Rintervals**
- **Sinus arrhythmia** (normal physiological phenomenon)
- **Deep inspiration : R waves closer : fast rate**
- **Deep expiration: bradycardia**

Heart rate

I. **Examine the distance between QRS complexes.**
II. **If the distances are regular, use one of these two formulas:**

$$\frac{300}{Big\ squares\ between\ R-R} \quad \text{Or} \quad \frac{1500}{small\ squares\ between\ R-R}$$

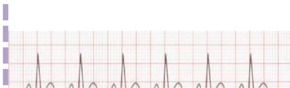
- **To obtain the heart rate in beats per minute.**

1 complex every 1 major division = 300/min

1 complex every 2 major division = 150/min

1 complex every 3 major division = 100/min

1 complex every 4 major division = 75/min



1 complex every 5 major division = 60/min

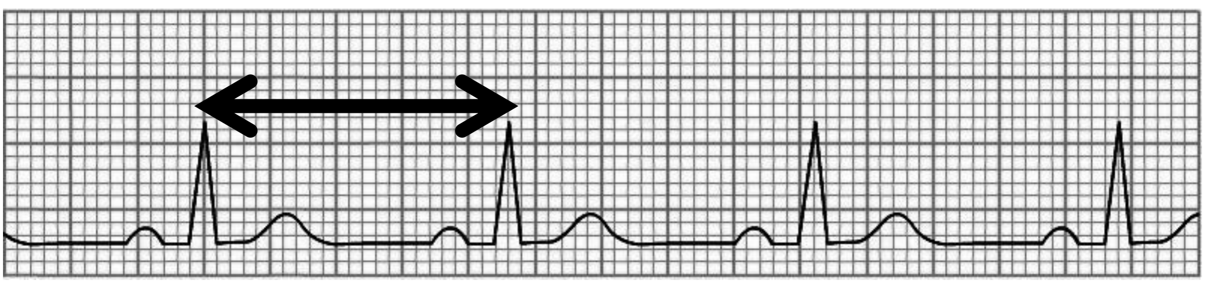
1 complex every 6 major division = 50/min

Calculation of Heart Rate :

We can calculate the heart rate from the ECG by using the following formula:

$$\text{Heart rate} = \frac{1500}{\text{Number of small squares between R} - \text{R waves}}$$

Where 1500 = the total number of small squares pulled by the machine every minute(60 secs) when he speed of ECG machine is calibrated at 25 mm/sec (60*25) and R-R interval = 1 heart beat.



In above the number of the small squares is 23 so we apply it to the formula:
1500/23 = 65 beats/minutes

1- The normal range of heart rate is between 60 – 100 beats/minute.
2- If the heart rate exceeds from 100 beats/minute, it is called **Tachycardia**.
3- If the heart rate goes below 60 beats/minute, it is termed **Bradycardia**.

Questions

Comment on the waves recorded with lead avR

The following ECG was recorded using 12 standard leads. Use lead II to calculate the following :
PR interval / QT interval / QRS duration / ST segment / HR / Rhythm (is it regular or not , is it sinus rhythm or not) / the cardiac axis use lead (I and III) or (1 and avF)

what events are occurring in the record during :
The PR interval?
The QRS complex?
The ST interval?

An ECG recording has been taken in which U wave is observed. What is U wave? what is it significance

Which of the following may cause prolonged QT interval?
Hypokalemia
Hyperkalemia
Hypocalcemia
Hypercalcemia

What is the major abnormality on this ECG?

Prolonged PR interval
Bradycardia
First degree heart block
Short QT interval

sinus tachycardia is seen during :
Deep inspiration or Deep expiration?

HEART SOUNDS

Objectives :

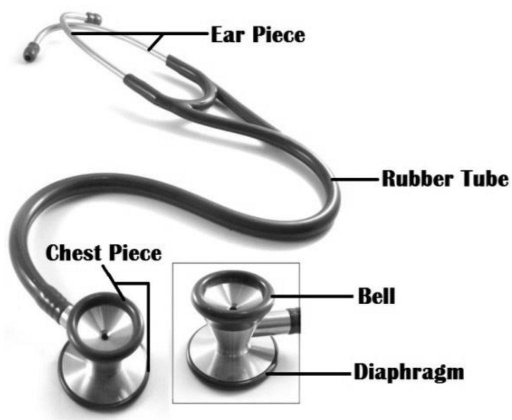
- To understand why the different heart sounds are produced.

- To know the sites at which heart sounds are best recorded.

- To recognize the value of phonocardiography.

Heart sounds using the Auscultation Method

The stethoscope :



The stethoscope consists of:

- Earpiece.
- Rubber tubing.
- Chest piece – consist of :
  1-Diaphrahgm (large circle) – Used with firm skin contact to hear the high frequency sounds.
  2-Bell (smaller circle) – Used with light skin contact and pressure to hear low frequency sounds.

NOTE:

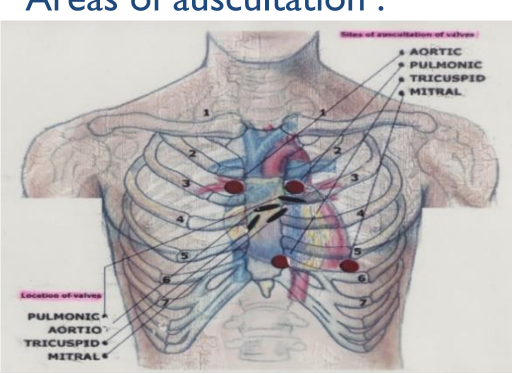
1. Both S1 & S2 are high frequency sounds while the murmurs are low frequency sounds.
2. A one-way valve system prevents sounds being transmitted by the bell when the diaphragm is being used and vice versa.

The position of the patient :

The heart should be auscultated when the patient is in the following positions:

- Supine. (lying face upwards)
- Left lateral.
- Sitting.

Areas of auscultation :



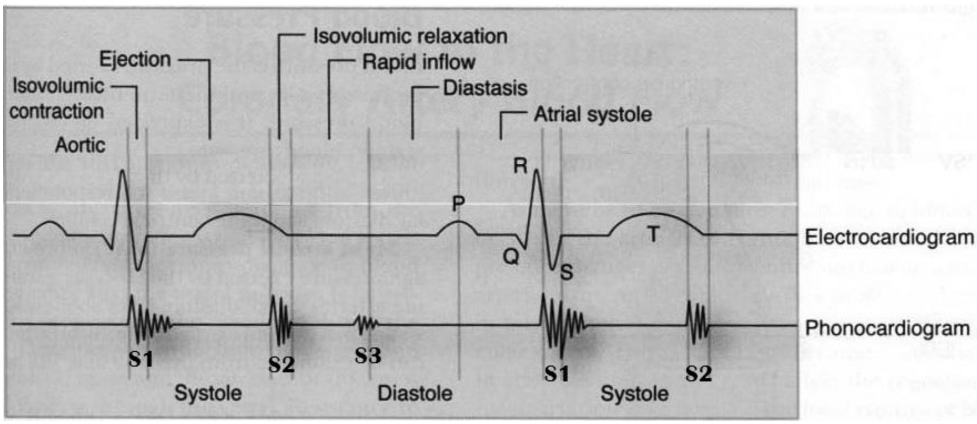
The following area should be auscultated for both NOROMAL and ABNORMAL (added) heart sounds:

1. The mitral Area: The site of the apex beat. This is found in the left 5th intercostal space, approximately 1 cm medial mid clavicular line.
2. The tricuspid Area: This is found just to the left of the lower border of the sternum.
3. The pulmonary Area: This is found in the left 2nd intercostal space at the sternal border.
4. The aortic Area: This is found in the right 2nd intercostal space at the sternal boreder.

Phonocardiography

Phonocardiography :

Phonocardiography is the sensitive technique, by which a recording can be made of all four heart sounds by placing a transducer on specific areas of auscultation.



First heart sound (S1) :

- The first and second heart sounds are audible , because they have high frequency .
- Humans can generally hear sounds with frequencies between 40 htz – 520 , less than 40 htz can't be heard

- It is always <u>normal</u>. It sounds as "lub". It is also called S1.
- It is usually prolonged, but dull in nature.
- It is caused by the closure of AV valves.
- It is best heard when auscultated at mitral and tricuspid areas.
- It occurs at the beginning of ventricular systole in relation to cardiac cycle.
- It occurs just after QRS complex if we relate it to ECG
- Frequency: 50-60 Htz
- Time: 0.15 sec

Second heart sound (S2) :

- It is always <u>normal</u>. It sounds as "dub". It is also called S2.
- It is usually short and sharp in nature.
- It is caused by the closure of semi-lunar valves.
- It is best heard when auscultated at aortic and pulmonary areas.
- It occurs at the beginning of ventricular diastole in relation to cardiac cycle.
- It occurs just after T wave if we relate it to ECG.
- Frequency:80-90 Htz
- Time: 0.11 sec

Third heart sound (S3) :

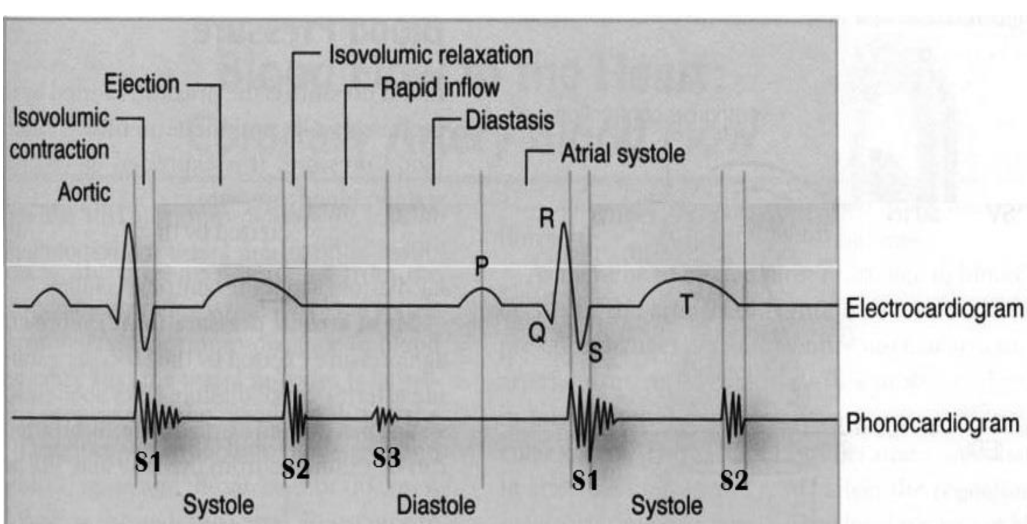
- It may be heard <u>normally in **children**</u>, thin adults, and pregnant women or after exercise.
- It is also called S3.
- It is caused by the striking of the blood to the wall of ventricles during rapid filling phase of ventricular diastole.
- It occurs in the early diastole in relation to cardiac cycle. (middle third of diastole)
- Frequency: 20-30 Htz
- Time: 0.1 sec

Fourth heart sound (S4) :

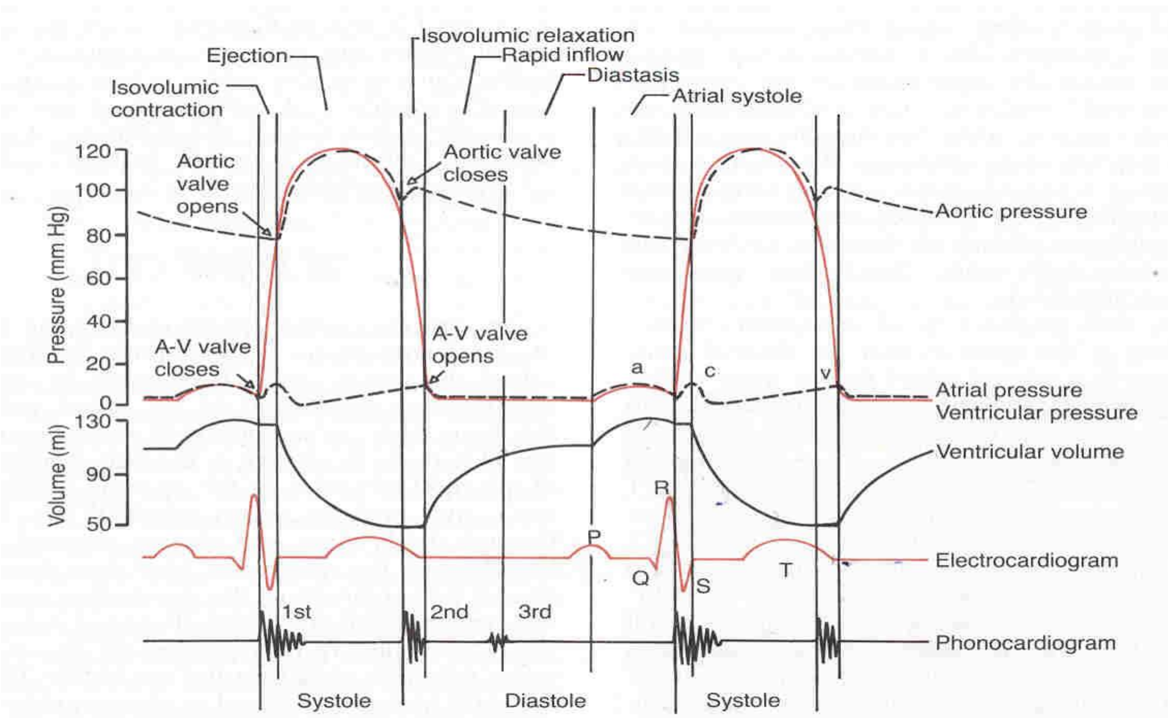
- It may be heard <u>normally in **older people**</u>.
- It is also called S4.
- It is caused by the forceful contraction of atria.
- It occurs just before the first heart sound during late diastole in relation to cardiac cycle.
- Frequency: < 20 Htz

Physiologically 3rd and 4th heart sounds both are not audible (cannot be heard)

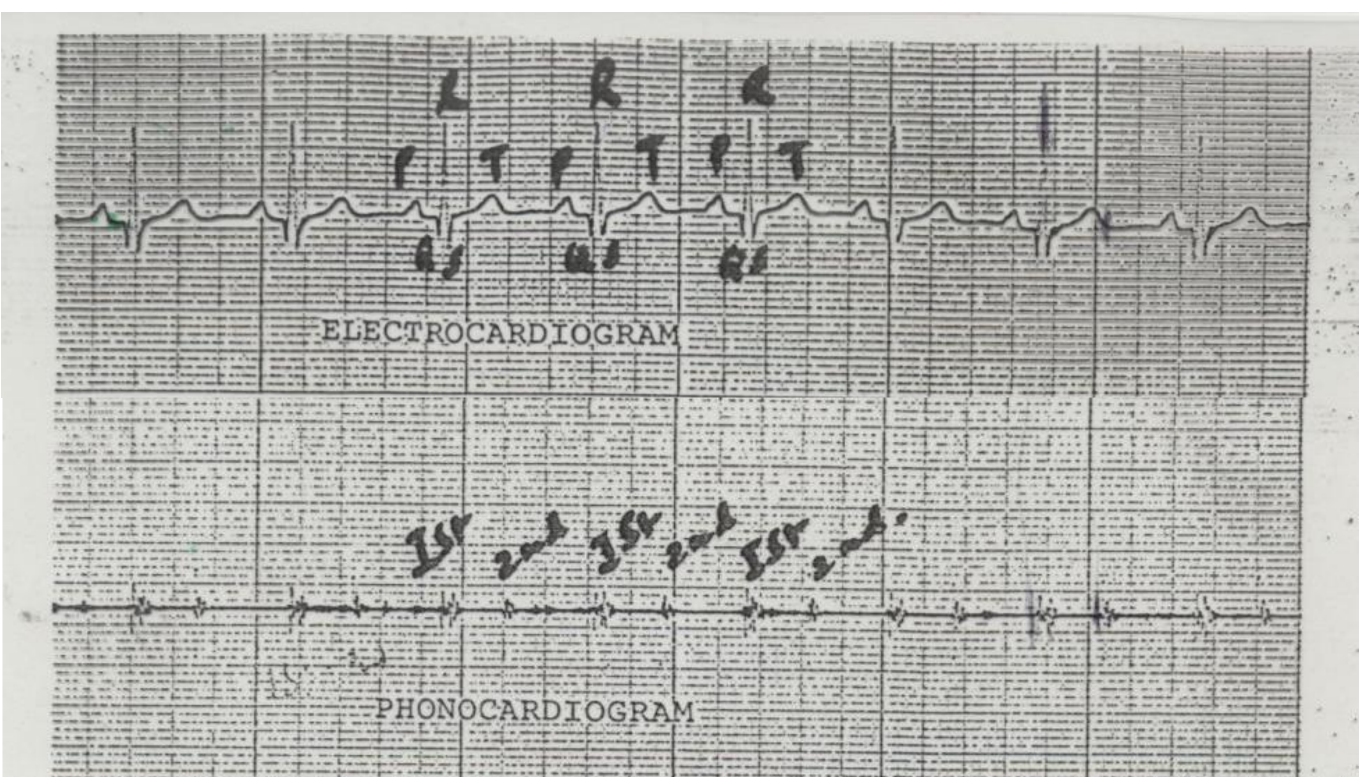
Heart sounds using Phonocardiography :



The Events of the Cardiac Cycle :



Relationship of heart sound with ECG :



Identification of heart sounds in a phonocardiogram :

We can identify the first and second heart sounds in a phonocardiogram by locating the periods of the ventricular systole and diastole.

1) As we know that the **first heart sound (S1) occurs at the beginning of systole** and **the second heart sound (S2) occurs at the beginning of diastole**, so the period between (S1) and (S2) should by systole and the period between (S2) and the next (S1) should be diastole.

2) Since the period of ventricular diastole is **longer** than that of ventricular systole in a cardiac cycle of a healthy individual, hence we can label the longer interval between the heart sounds as "diastole" and the shorter as "systole".

3) Once systole and diastole are located we can easily label the heart sound occurring at beginning of systole as "S1" and the heart sound occurring at the beginning of diastole as "S2".

So to recap, we can identify the heart sounds based on their character and time interval of separation.

Splitting of the second heart sound A2-P2

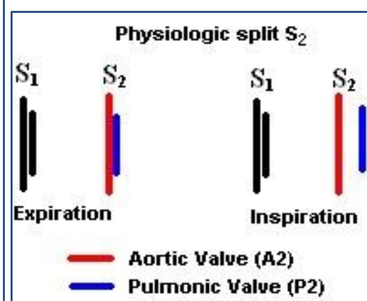
- Physiologic **splitting** of the 2nd **heart sound** is a normal phenomenon that occurs during **deep inspiration** when the **A2** component splits from the **P2** component by more than **0.2 seconds**.
- It is auscultated as "**dub, dub**" over the **aortic** or **pulmonary** areas.

- If either the first or second head sound has two distinct components, they are said to be split .

- Indeed, second heart sound splitting is a normal physiological phenomenon that may occur during deep inspiration.

- As a person takes a deep breath, the chest wall expands and the intra-thoracic pressure falls due to which superior and inferior venae cavae becomes dilated and more blood returns to the right atrium.
Because of more filling of the right ventricle as compared to the left ventricle during deep inspiration, the right ventricle takes more time to contract and empty during systole, so the pulmonary valve will close a little later than aortic valve that will cause splitting of the second heart sound.

- We can hear a clear "dub, dub" when we auscultate the heart at either aortic or pulmonary areas during deep inspiration. This is what we call physiological splitting of the second heart sound. Although this splitting can only be appreciated by the human ear only if the two components of the sound are separated by more than 0.2 seconds .

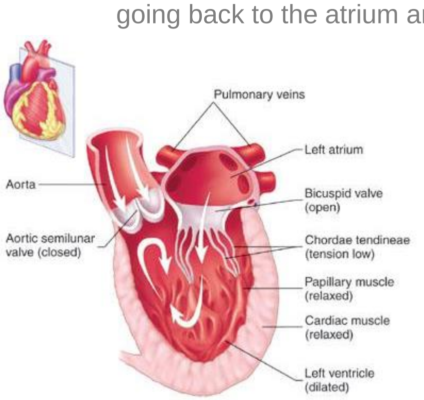


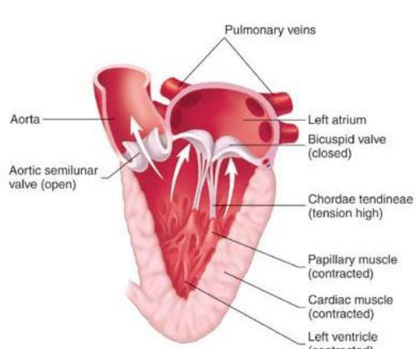
Heart Murmurs

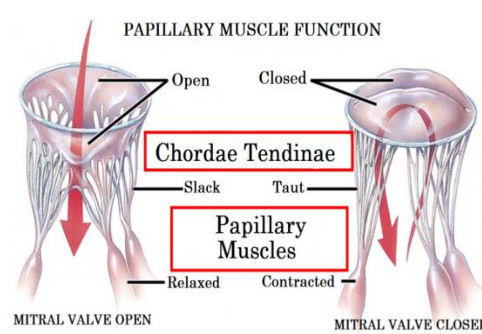
- Murmurs are **abnormal** sounds produced due to **abnormal flow** of blood through **abnormal heart valves** e.g. stenosis or regurgitation. Like in rheumatic fever

Function of papillary muscle & Chordae tendinea

- When the papillary muscles are relaxed the valve will be opened and the blood will flow from the atrium to the ventricle, after than when it contracts the valve will close to prevent the blood from going back to the atrium and the blood will be pumped to the semi lunar valve.







The recording of jugular venous & carotid arterial pulses

Objectives :

- The events causing the different waves of the JVP & CAP tracings.
- Difference between JVP and CAP.
- Correlation between JVP, CAP, ECG and Phoncardiogram.

Jugular venous and Carotid arterial pulses

Jugular venous and Carotid arterial pulses :

- The **carotid pulse** tells about the **aorta** and **left ventricular** function.
- **JVP** provides information regarding hemodynamic changes in the **right side of the heart**.
- Evaluation of pulse waveform helps in the diagnosis of certain cardiac diseases & assessing their severity.

Distinguishing features between venous and arterial pulses :

Jugular venous pulse (JVP)	Carotid arterial pulse (CAP)
Visible but **not** palpable	Palpable
Obliterated by pressure	**Not** obliterated by pressure
2 pulsations per systole	**1** pulsation per systole
Decreases with inspiration	No effect of respiration
Enhanced by H-J-Reflex	No effect of abdominal pressure

Carotid arterial pressure :

The carotid pulse can be taken on the **right side of the neck** over the carotid artery in order to determine heart rate.

When blood is forced into the aorta during ventricular systole, two things happen:

1. Blood is moved forwards.

2. A pressure wave is set up which travels along the wall of arteries (faster than the flow of blood), expanding the arterial walls as it travels. The expansion of the arterial wall is palpable as the pulse.

How to examine :

1) Subject supine at 30° head slightly bent to the examined side.

2) Feel CAP on medial side of SCM alongside the lateral border of thyroid cartilage.

3) Apply transducer over CAP using soft rubber band and connect it to recorder.

For better understanding you can watch these videos: 1, 2, 3

Recorded CAP graph

Anacrotic limb (ANA means up) : rapid upstroke

It is an upward deflection recorded in the carotid arterial pulse tracing representing continuously increasing pressure in the carotid artery <u>during the maximum ejection phase</u> of ventricular systole.

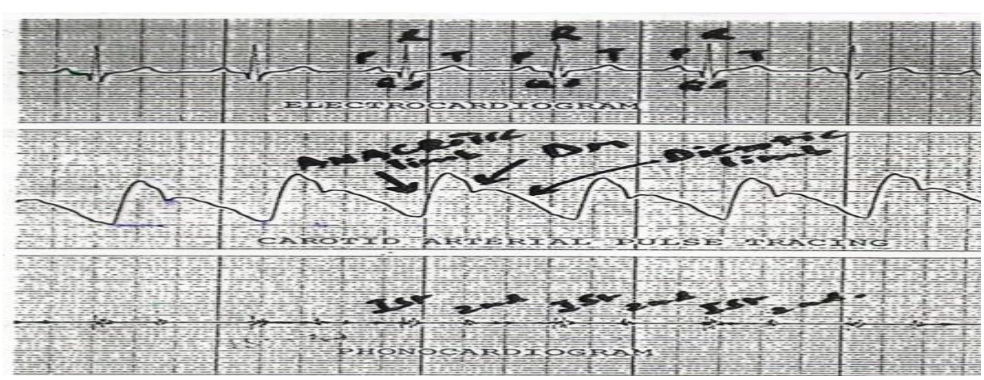
In healthy individuals, the arterial pressure recorded at the peak of the anacrotic limb is 120 mmHg.

Dicrotic Notch (Dn) or Incisura :

It is recorded in the carotid arterial pulse tracing when the continual fall in the arterial pressure is interrupted by the closure of the aortic valve at the end of ventricular systole.

It marks the beginning of ventricular diastole.

We can easily find that it coincides with the second heart sound when we relate it to a phonocardiogram and occurs just after the T-wave when we relate it to an ECG, as can be seen in the following figure:



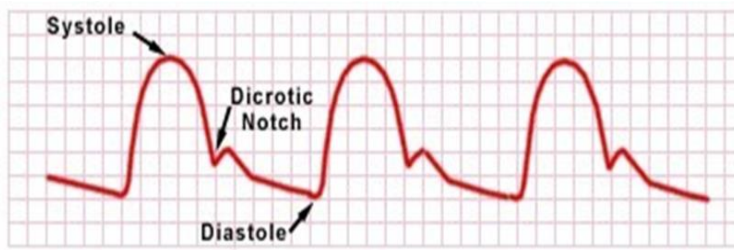
Dicrotic limb :

It is the falling phase of the carotid arterial pulse tracing after the incisura.

It is caused by the continual decreasing pressure in the carotid artery during the ventricular diastole, but the pressure does not fall all the way to 0 mmHg, but stops falling further when it reaches 80 mmHg due to the elastic recoil of the arterial wall.

Duration :

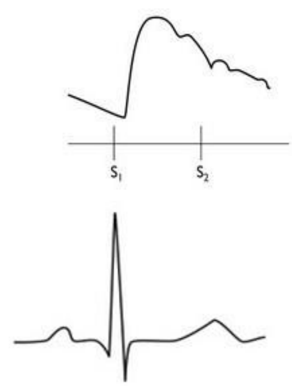
Cardiac Cycle duration	**0.8 sec**
Ventricular **systole**	**0.3 sec**
Ventricular **diastole**	**0.5 sec**



CAP and ECG

Dicrotic Notch (Dn) or Incisura :

Coincides with the second heart sound when we relate it to a phonocardiogram and occurs just after the **T-wave** when we relate it to an **ECG**.



Abnormal CAP : this will make changes in the tracing of the pulse

Aortic stenosis ⟶ pressure drops

Aortic regurgitation ⟶ pulse strong

Jugular Venous Pressure

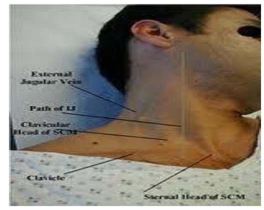
Jugular Venous Pressure

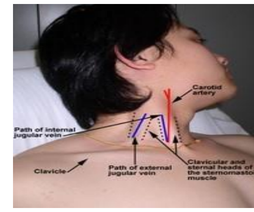
Before reading these slides we recommend to watch this great video for better understanding.

- Pressure changes in **the right atrium** are transmitted directly to the **internal jugular vein (IJV)** as there are **no valves** between this vein and the right atrium.
- The external jugular vein is **easier** to see but **has valves** and is subject to compression as it enters the chest (tortuous course).

How to examine the patient:

- Use the right IJV.
- Patient at a 45° angle.
- Head turned slightly to the left.
- IJV runs from medial end of clavicle to the ear lobe
- under medial aspect of the SCM.
- Find its pulsation between the 2 attachments of SCM.
- More prominent with Valsava manoeuvre





Pressure changes in the right atrium are transmitted directly to the internal jugular vein as there are no valves between this vein and the right atrium. The external jugular vein cannot be relied upon because this vessel :

a) Has valves

b) May be obstructed by the fascial and muscular layers

JVP waveform

Classically 3 visible peaks (waves) and 2 visible descents/troughs. And they are caused by:

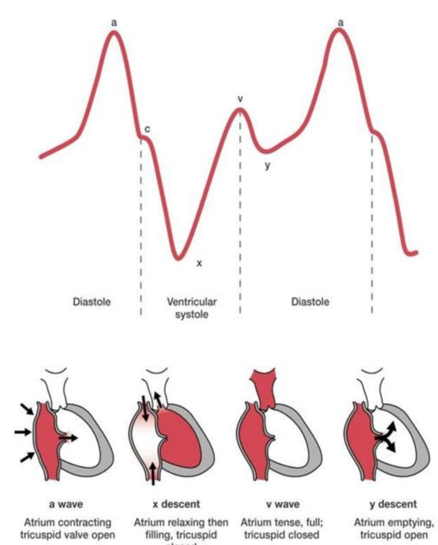
- **'a' wave: right atrial systole.**
Right atrial contraction in late diastole to propel additional blood into ventricles.

- **'c' wave:** transmitted manifestation of the rise in atrial pressure produced by bulging of tricuspid valve into the right atrium during isovolumetric ventricular contraction.

- **'x' descent: atrial relaxation**.
Due to downward displacement of the tricuspid valve by the contraction of papillary muscles during ventricular systole.

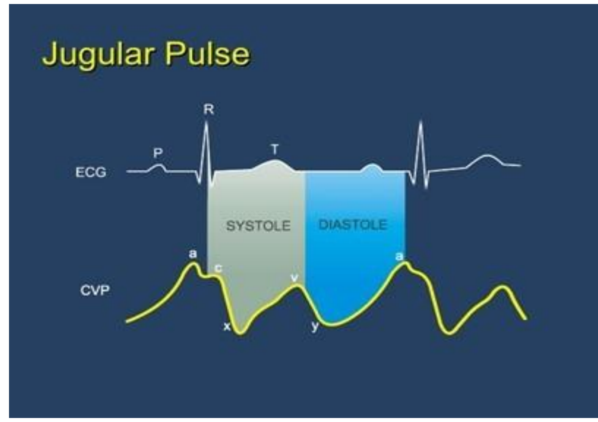
- **'v' wave:** rise in atrial pressure by venous return before tricuspid valve opens.

- **'y' descent: tricuspid valve opens.** Passive rapid ventricular filling, decreasing right atrial pressure.



How to identify JVP tracing ?

1. **First** identify v wave, you will find it between two descents x & y.
2. The “a & c wave” precede the x descent.
3. x more prominent than y.
4. c, x and v are SYSTOLIC. y and a are DIASTOLIC.



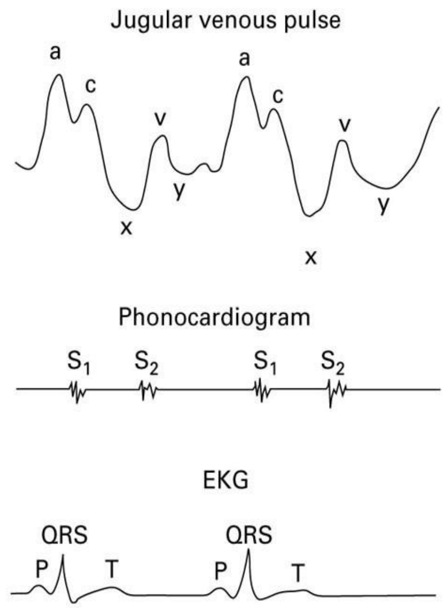
Correlations :

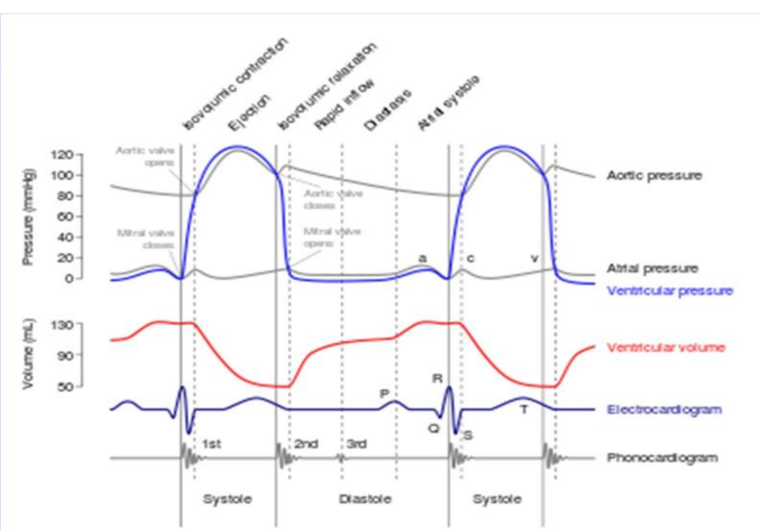
a wave:

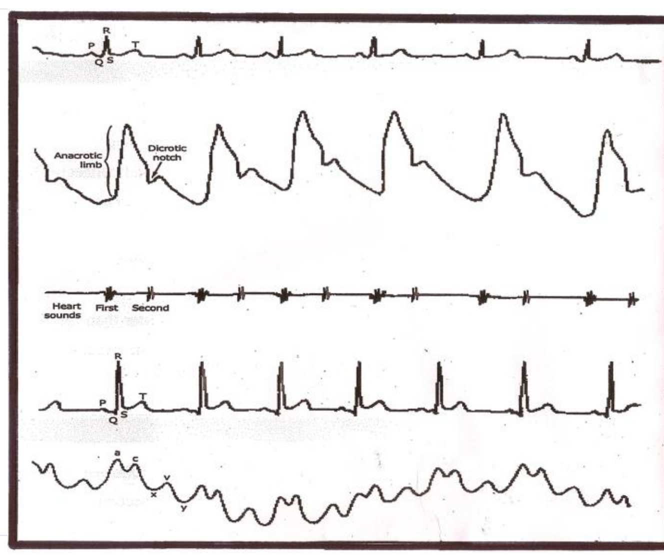
- Follows P wave of ECG.
- Precedes upstroke of carotid pulse.
- Just before S1.

c wave follows QRS and S1.

v wave peaks after S2 which is synchronous with dicrotic notch (late systole).







Clinical Application (Abnormalities):

a wave:

- Prominent: In any of the following conditions, "a" wave will become large in amplitude due to the increased right atrial pressure caused by a forceful right atrial contraction:
  - ❖ Right heart failure
  - ❖ pulmonary stenosis
  - ❖ Pulmonary hypertension
  - ❖ Tricuspid stenosis.
- Absent: When the right atrium pressure cannot be increased by right atrial contraction, the "a" wave will not be formed and will be absent such as in Atrial fibrillation.
- Cannon wave: When the amplitude of "a" wave becomes too high, it is called cannon Wave and it happens when the right atrium contract against a closed tricuspid valve. This can be seen in the following conditions:
  - ❖ Complete AV block (Third degree heart block)
  - ❖ Atrial flutter
  - ❖ Ventricular tachycardia

c wave Prominent in tricuspid regurgitation.

v wave "v" wave can become large or more prominent in "tricuspid regurgitation" when the right atrial pressure is increased too high by the leaking blood into the right atrium from the right ventricle through the incompetent tricuspid valve during the ventricular systole.

Questions

1 / to which phase of the cardiac cycle corresponds the anacrotic limit of the carotid arterial pulse (CAP)?

2/ the dicrotic notch of the CAP corresponds to which heart sound (1 or 2)?

3/ what cause each wave or descent in the jugular pulse?

4/ which of the following is correct?
A wave follows QRS complex of the (F)
C wave follows QRS (T)
Y descent occur in systole (F)
V wave peaks just after s1 (F)

5 / in which condition a cannon wave “a” is seen?

6 / in which condition an absent cannon wave “a” is seen?

Blood Pressure

Objectives :

- To be able to measure arterial blood pressure using a sphygmomanometer .

- To recognize the effects of exercise on the arterial blood pressure .

Blood pressure

Blood pressure :

The force exerted by the blood against any unit area of the vessel wall .

Bl. Pressure 50mmH : Means that the force exerted is sufficient to push a column of mercury against gravity up to a level of 50mmHg high.

Normal systolic pressure ranges from 100 to 140 mm Hg.
Normal diastolic pressure ranges from 60 to 90 mm Hg.

Equipment :

1- A stethoscope
2- A sphygmomanometer
3- A bicycle and/or a treadmill

> The patient should be at physical and mental rest 5 minutes before taking blood pressure measurement .
> The patient should be at comfortable position .

Measurement of arterial blood pressure :

Precautions for measuring arterial blood pressure :

- The cuff size should be appropriate for the age and built of the subject. A large cuff is recommended for obese subjects while a smaller one is available for use with children.

- The cuff must be applied snuggly (not too tight and not too loose) about 4 cm above the cubital fossa.

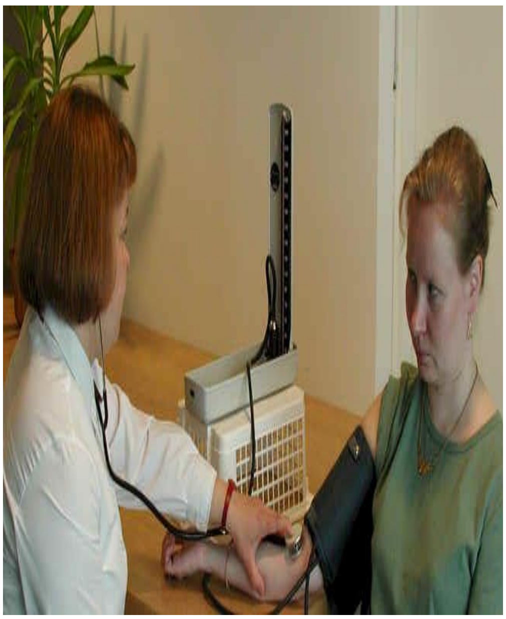
- Take care that the free margin of the cuff is not on the course of brachial artery i.e. to make sure that the rubber bag within the cuff is on the medial side so that it can occlude the brachial artery when the cuff is inflated.

- It is important that the manometer should be at the same level as the heart to exclude the effect of gravity while measuring the blood pressure.
The mercury manometer should be in the vertical position .

- Check that there is an adequate amount of mercury in the bulb of the instrument. This can be done by seeing whether the mercury level is at the zero position of the manometer.

- The subject must be physically and mentally relaxed and in a comfortable environment .

Palpatory Method : (This method only gives an estimate of the systolic blood pressure)



- The subject's arm should be resting comfortably so that it does not need to be actively supported while the blood pressure is being taken.
- A standard cuff (12 x 24 cm) is applied like a bandage (ضمادة) about 4cm above the elbow joint.
- Inflate (تضخيم) the cuff until the radial pulse cannot be felt. By compressing the brachial artery, the pulse or pressure wave can no longer be transmitted to the radial artery.
- Deflate(تفريغ) the cuff slowly. Note the pressure at which the radial pulse can be felt again for the first time. This will be the systolic blood pressure.

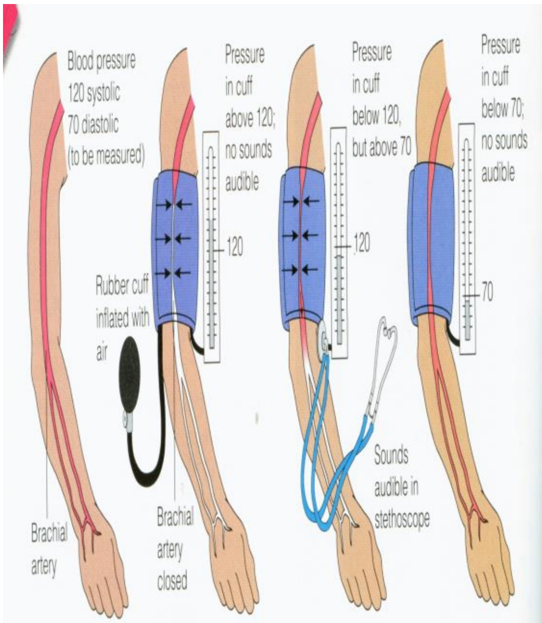
Auscultatory Method : (This method measures both systolic and diastolic blood pressures)

- Inflate the sphygmomanometer cuff until there is no radial pulsation.

- Place the diaphragm of the stethoscope over the brachial artery just above and on the medial side of the elbow joint.

- Deflate the cuff slowly. A series of sounds are usually heard which called **Korotkov sounds** .

The korotkov sounds : These sounds are produced by turbulent flow in the constricted brachial artery.



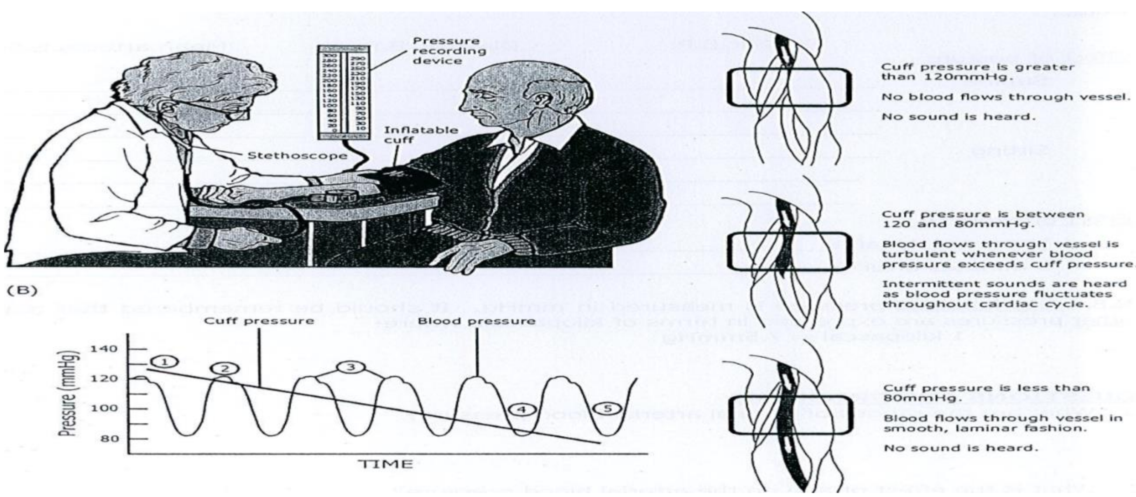
Phase 1: The appearance of a clear tapping sound. This is the first sound that is heard and it represents the Systolic Pressure.

Phase 2: Blowing or swishing (rushing sound) sounds.

Phase 3: The sounds become sharper and crisper.

Phase 4: An abrupt muffling (يخف فجأة) of sounds.

Phase 5: All sounds disappear. The point where the sound disappears is the diastolic blood pressure.



Procedure :

- Practice the above two methods while the subject is resting in a supine position and then in the sitting position.
- Repeat each measurement <u>at least three times</u> to establish the reproducibility of the results.
- After about 10 minutes of exercise on either a bicycle ergometer or a treadmill, the blood pressure of the subject should be determined both immediately and 5 minutes after exercise.

The pulse pressure :

It is the difference between systolic and diastolic blood pressures.

Systolic pressure = 120 mmHg and Diastolic pressure = 80 mmHg; then
Pulse Pressure = Systolic – Diastolic pressure i.e. 120 – 80 = 40 mmHg.

The mean arterial blood pressure :

It is the average blood pressure within the arteries during a whole cardiac cycle and it is the force responsible for maintaining a continuous forward flow of the blood in the circulation during the whole cardiac cycle.

(M.A.B.P) = diastolic blood pressure + 1/3 pulse pressure

For example patient with 120\90 bp: the pulse pressure = 120 - 90 = 30 mmHg and then the mean arterial blood pressure = 90 (diastolic) + 1/3 (30)

The effects of exercise on the systolic & diastolic blood pressures :

- **MILD TO MODERATE EXERCISE :**

Systolic BP increases, while Diastolic BP remains the same.
Because of sympathetic stimulation, the cardiac output increases, which in turn **increases the systolic BP, but NO EFFECT on diastolic BP.**

- **SEVERE OR HEAVY EXERCISE :**

Systolic BP increases further and Diastolic BP DECREASES
More sympathetic stimulation will increase the Systolic BP further and the Diastolic BP drops because of a net decrease in the total peripheral resistance due to the more vasodilatation effect on the arterioles supplying the exercising skeletal muscles than the vasoconstriction effect on the arterioles supplying the other tissues.

Condition	Blood Pressure Reading
Before Exercise	120/80 mmHg
After Mild To Moderate Exercise	140/80 mmHg
After Heavy (Severe) Exercise	160/60 mmHg

Factors affecting blood pressure :

Posture:
In erect posture: the systolic falls a little but soon returns to normal by the compensatory mechanisms. مثل لما الواحد يقوم فجاة ويحس بدوخة

Age

Blood pressure increases with age:

- At birth: 50\30
- Adult: 120\80
- Old age: 170/90

Exercise

Systolic blood pressure increases while diastolic blood pressure remains unchanged

Body build

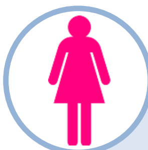
Obesity increases blood pressure.

Diurnal variation

Blood pressure is lower in the morning.

Digestion

Systolic blood pressure rises by 6-8 mmHg after meals (1hour)



Sex

Blood pressure is lower in the **females** before menopause.

Temperature

Cold causes vasoconstriction so increases the blood pressure due to increase peripheral resistance.

Emotions

Increases blood pressure.
It drops while sleeping and excessive hemorrhage.

Dr.Ola's note :
before menopause females are less susceptible to hypertension than males and after menopause both sex are equally affected or even female become more susceptible to hypertension

Questions and problems

1. What are the range of normal blood pressure?

-Systolic BP : 100 - 140 mmHg
-Diastolic BP : 60 - 90 mmHg

2. explain how korotkov sounds are produced?

-When the brachial artery is partially occluded, the blood flow through it becomes turbulent, which produces vibrations that ae heard auscultation.

3. What is the pulse pressure?

-It is the difference between the systolic and diastolic blood pressers.
Systolic pressure =m120 mmHg and diastolic pressure = 80 mmHg; then pulse pressure = systolic – diastolic pressure i.e. 120 - 80 = 40 mmHg.

4. What is the mean arterial blood pressure? What is its significance?

-It is the average blood pressure within the arteries during a whole cardiac cycle and it is the force responsible for maintaining a continuous forward flow of the blood in the circulation during the whole cardiac cycle.

5. How can we calculate the mean arterial blood pressure? give an example.

-Because the diastole phase of a cardiac cycle is longer than its systole phase, that is why we cannot apply mathematical average to determine the mean arterial blood pressure; instead we can calculate the mean arterial blood pressure (M.A.B.P.) by applying the following formula:

$$\text{M.A.B.P.} = \text{diastolic blood pressure} + \frac{1}{3}\ \text{pulse pressure}$$

Let us suppose that a subject's blood pressure is measured to be 120/9O mmHg then we can calculate the mean arterial blood pressure in the following 3 steps
1) Determine the pulse pressure : 120 90 30 mmHg
2) Divide the pulse pressure by 3 : 30/3 10 mmHg
3) Add the above answer to the diastolic blood pressure: 10 + 90 = 100 mmHg So 100 mmHg will be the mean arterial blood pressure in this example .

6. What are the effects of exercise on the systolic & diastolic blood pressures? what happens to the pulse pressure? explain why these changes occur.

Mild to moderate exercise	Sever or heavy exercise
Systolic BP increases, while diastolic BP remain the same.	Systolic BP increases further and diastolic BP decreases
Because of the sympathetic stimulation, the cardiac output increases, which in turn increases the systolic BP, but no effect on diastolic BP.	More sympathetic stimulation will increase the Systolic BP further and the Diastolic BP drops because of a net decrease in the total peripheral resistance due to the more vasodilatation effect on the arterioles supplying the exercising skeletal muscles than the vasoconstriction effect on the arterioles supplying the other tissues.

Girls team :

Monera Alayuni

Monirah Alsalouli

Alanoud AlOmair

Johara Almalki

Demah Alrajhi

Boys team :

Rawaf Alrawaf

Abdulnasser Alwabel

Fahad Alabdullatif