The Cardio-VASCULAR System

- ○ Anatomy
- ○ Histology
- ○ Pathology
- ○ Pharmacology
- ● Physiology
- ○ Microbiology

Lec #: 7

Dr. Name: Faisal.m

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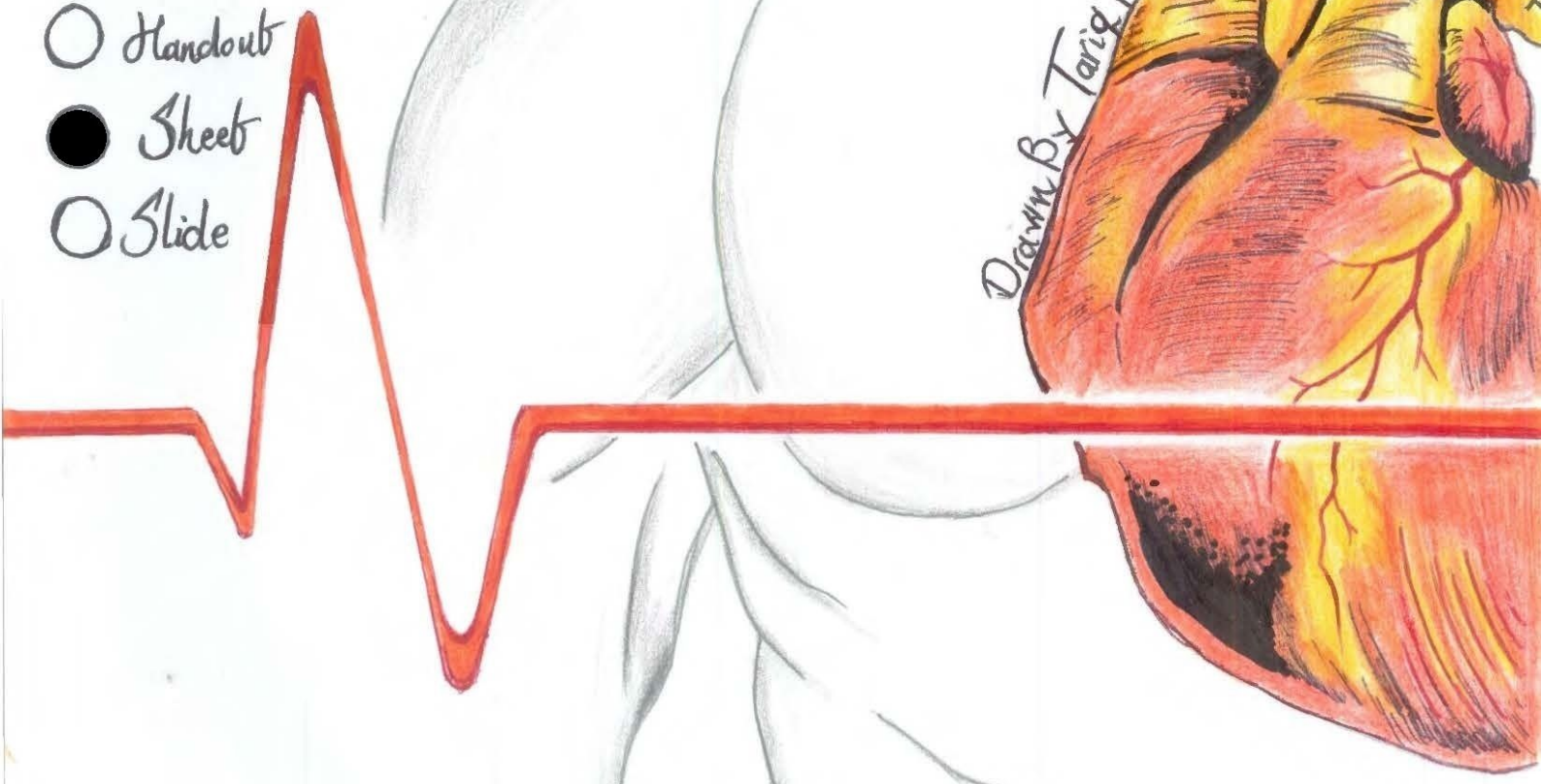
- ○ Handout
- ● Sheet
- ○ Slide



ELECTROCARDIOGRAPHY - 3

❖Mean Electrical Axis (MEA)

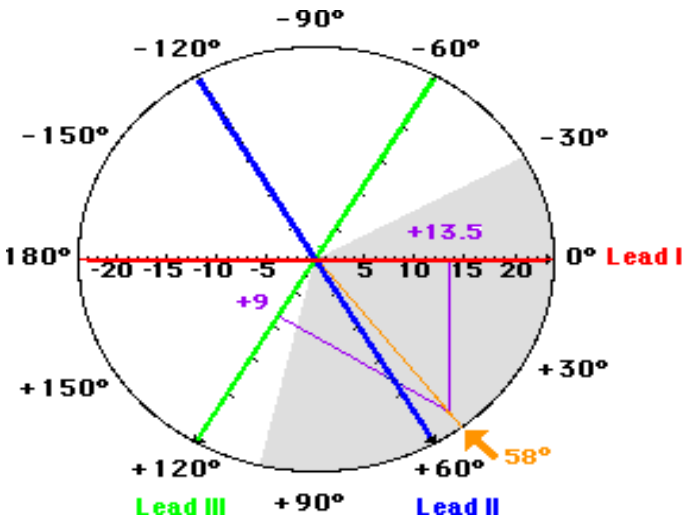
Last time we started talking about **Mean Electrical Axis** so let's continue:

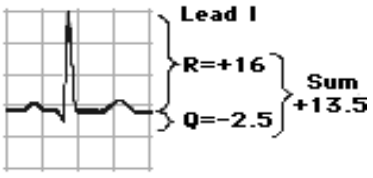
- ✓ The MEA is the principal vector of **ventricular depolarization.**
- ✓ It is Calculated from 2 different limb leads (any 2 limb leads whether unipolar or bipolar). We should know the axis of the leads:

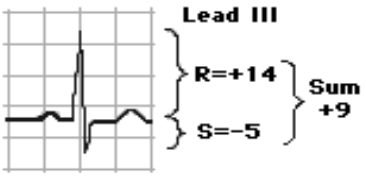
> - ➢ Axis of **lead I** : from **0 to 180**
> - ➢ Axis of **lead II** : from **+60 to -120**
> - ➢ Axis of **lead III** : from **+120 to -60**

- ✓ Now let's discuss the details of the calculation. When you look to ECG paper , you algebraically summate the QRS (Measure the **sum** of the **height** and the **negative depth** of the QRS complex). Let's take some examples.

Example #1 :







- In this example we will take lead I and lead III (remember that you can take any 2 leads)
- For **lead I**:

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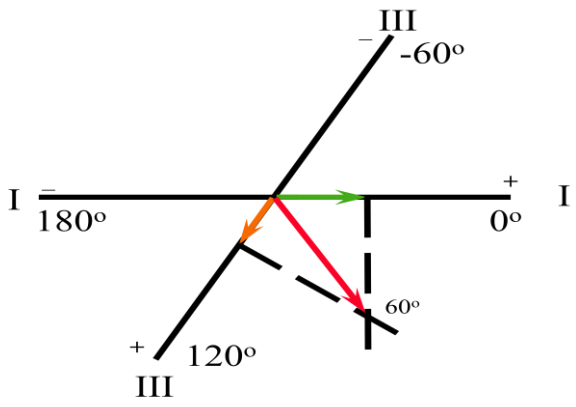
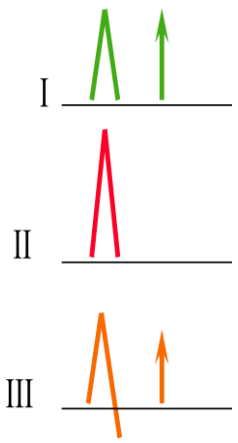
* First you ask yourself how much is the R wave ? when we say "how much" this refers to how many small squares represent the R on ECG paper (Remember that the paper is divided into squares for the sake of counting them). **R is positive (height)** . In this example it is equal to +16.
* Now you look for the Q. **Q is negative (depth)**. In this example it is equal to -2.5.
* Take the summation of R and Q → (+16) + (-2.5) = (+13.5)
* Go to the graph and draw a perpendicular line onto the axis of lead I at the point of +13.5.

- For lead III :
  * R is +14
  * S is -5 **(Notice that in lead III there is no Q so the summation would be equal to (R+S) and in case of lead I there was no S so the summation was equal to (R+Q))**
  * Summation → +9
  * Again, go to the axis of lead III and draw a perpendicular line onto the axis at the point of +9.
- The two perpendicular lines you drew for each lead should intersect (they aren't parallel lines that's why they have to intersect). Draw a **line between the center of the circle and the point of intersection**. This is the line of MEA. Then measure the **angle between axis of lead I and this line**. This is the angle of MEA. In this example the angle is equal to +58 which is normal. **It is considered normal if the angle is between -30 and +110**.

Example #2 :



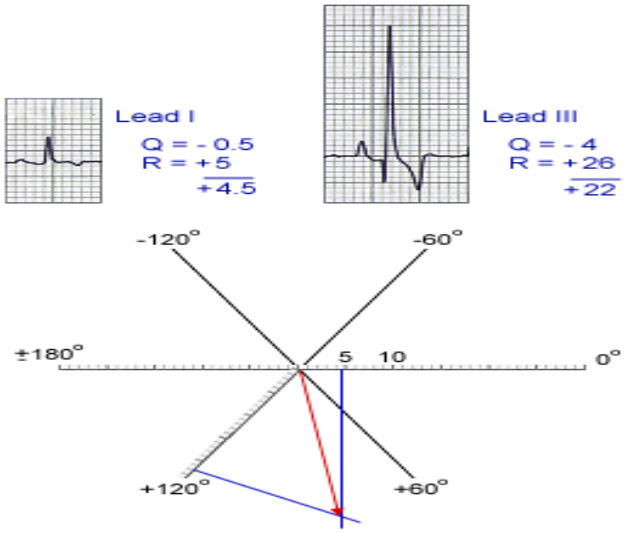


- In this example we also used lead I and lead III. The summation for each lead was measured and perpendicular lines were drawn. A line between the center and point of intersection is drawn and the angle between axis of lead I and this line is measured. The angle of MEA here is equal to +60 which is normal.

- If you take lead I and lead II for example, the point of intersection should be similar to that resulting from lead I and lead III. So **whatever were the two leads you have taken, the point of intersection should be the same and as a result angle should be the same**.

- In this example MEA was measured according to lead I and lead III values. Suppose that you are asked to find the value for lead II in this example. you have MEA line so you can easily draw the axis of lead II then draw its perpendicular line and this perpendicular line represent the value of lead II. The same applies for other leads (aVR/aVL/aVF).

Example #3 :

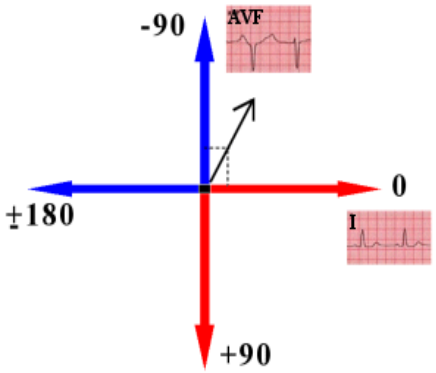


- For lead I :
  - Q= -0.5
  - R= +5
  - Sum = +4.5
  - Draw perpendicular line onto the axis of lead I at the point of +4.5

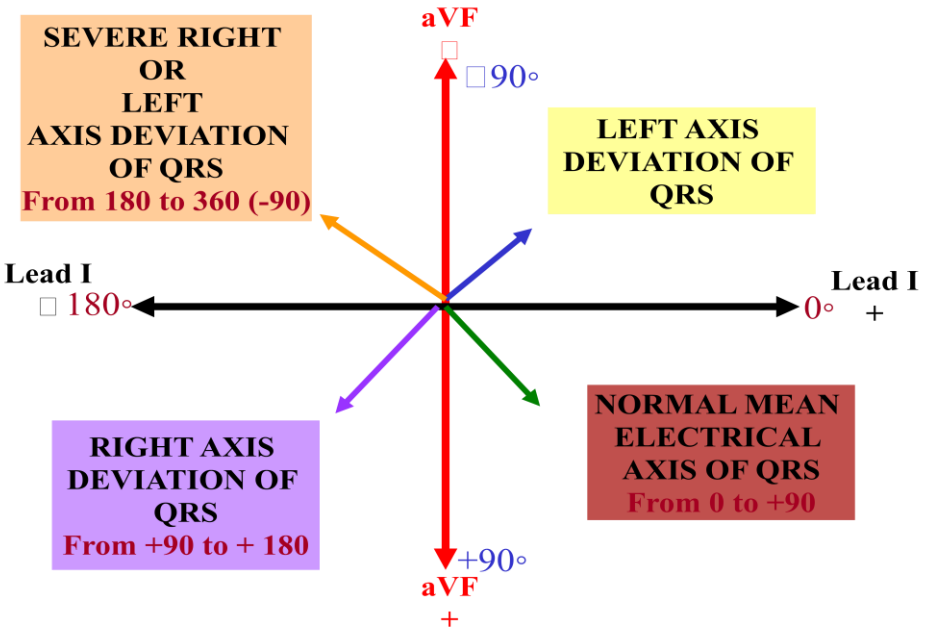
- For lead III :
  - Q= -4
  - R= +26
  - Sum = +22
  - Draw perpendicular line onto the axis of lead III at the point of +22

- Draw a line between the center and the point of intersection and measure the angle of MEA between axis of lead I and line of MEA.

Example #4:



- In this example we will use lead I and aVF.
- These two leads are perpendicular to each other.
- If **lead 1 is positive** and **aVF is positive** , the intersection will be in the area between 0 and +90 . This is considered **normal**.
- If **lead I is negative** and **aVF is positive** , the intersection will be in the area between +90 and 180 This is the case of Right **axis deviation of QRS**.
- If **lead I is positive** and **aVF is negative**, the intersection will be in the area between 0 and -90 .This is the case of **left axis deviation of QRS**.
- If **lead I is negative** and **aVF is negative**, the intersection will be in the area between -90 and 180. This is the case of **severe right or left axis deviation**. **To know whether it is right or left you need to ask the patient. If he complains from the right sided heart then it is severe right axis deviation. If he complains from left sided heart then it is severe left axis deviation.**



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❖Heart Rate Calculation

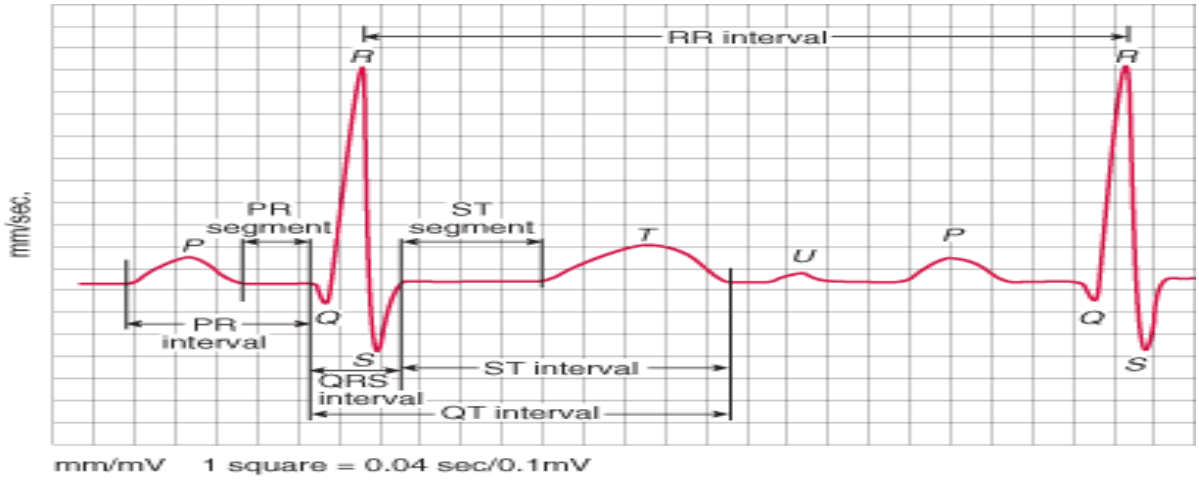
- To calculate Heart rate first you need to measure R-R interval.
- **R-R interval = number of small squares representing the interval on ECG paper × 0.04**
- Remember that: 1 square = 0.04 second/0.1mV
- **Heart rate (beats/minute) = 60 (second/minute) / R-R interval (second/beat)**
- If R-R interval is equal to 0.83 then:

HR = 60 / 0.83 = 72

- If R-R interval is equal to 0.6 then:

HR = 60 / 0.6 = 100

❖ECG Calculations



- ECG calculations include : (Intervals + Segments)

1) **PR interval**
2) **QRS interval**
3) **ST interval**
4) **QT interval**
5) **PR segment**
6) **ST segment**

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First: PR or PQ Interval

- PR interval is measured **from beginning of P wave to the beginning of Q wave** by counting how many small squares lie in this area and multiplying the number of squares by 0.04.
- **Norma**l PR interval is **up to 0.2** second
- If PR is equal to **0.25** then the patient has **AV block (first degree heart block and here each P wave should be followed by QRS complex)**.

Second: QRS interval

- QRS interval should be **normally below 0.12** second
- If it is **higher than 0.12** then the patient has one of the following:

1) **left bundle branch block or right bundle branch block**.

- Why left bundle branch block or right bundle branch block might prolong QRS interval?

Because if we have left or right bundle branch block, the ventricular muscle will get depolarized by ventricular cells and speed of conduction of ventricular cells is slow (0.3-0.5 m/second compared to 4 m/second in perkinji fibers) so the depolarization in ventricles takes longer time.

2) **Hypertrophy of ventricles resulting from hypertension.** In Hypertrophy the volume of ventricular muscles increase which means an increase in the time needed for depolarization and as a result prolonging the QRS interval.

Third: QT interval

- QT interval depends on the heart rate.
- It is Normally around 0.35 second.

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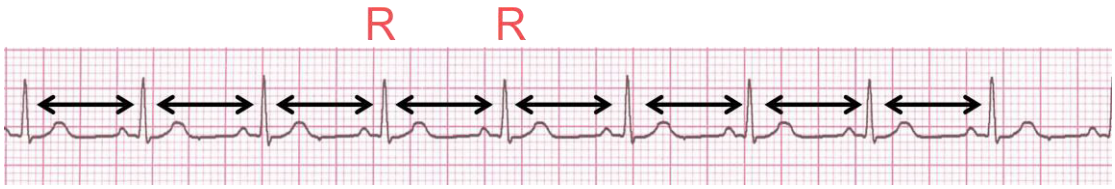
➢ A prolonged QT interval is indicative of repolarization abnormalities which increase susceptibility to various ventricular arrhythmias.

⌘Fourth: ST segment

➢ Whether you have **depression or elevation of ST segment**, **both** cases denotes **Ischemia**. (you might see ST segments in the same patient elevated in some leads and depressed in other leads and this depends on the axis of the leads)

❖Determining regularity of heart rhythm



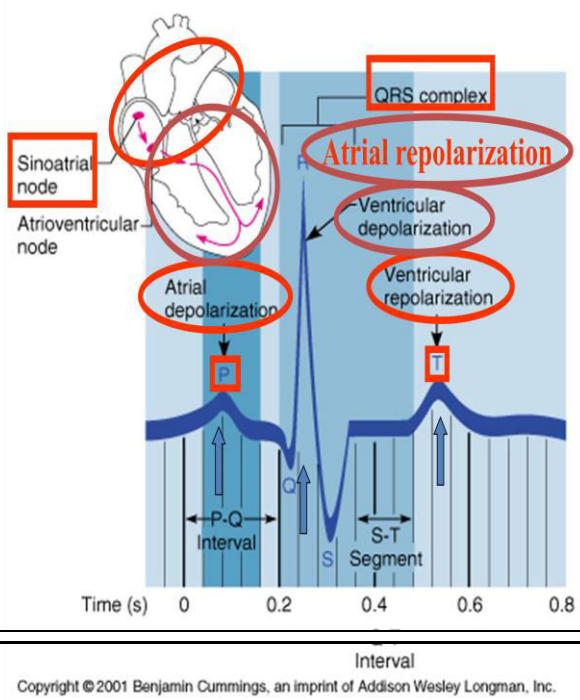
✓ To determine if heart rhythm is regular or irregular you measure the distance (how many small squares) between each two successive R waves. If they are all the same, the heart rhythm is **Regular**.

✓ If they aren't all the same, heart rhythm is **Irregular**. Irregularity of heart rhythm is of two types:

1. **Regular irregularity** : the irregularity repeats its self as a pattern (in a regular manner). This is seen in case of ***second degree heart block.***
2. **Irregular irregularity**: seen in case of ***third degree heart block.***

❖ECG deflection waves:

(Pacemaker)



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➢ This is a revision of what we've taken in previous lectures:

✓ Typically an ECG has five deflections, arbitrarily named "P" to "T" waves.

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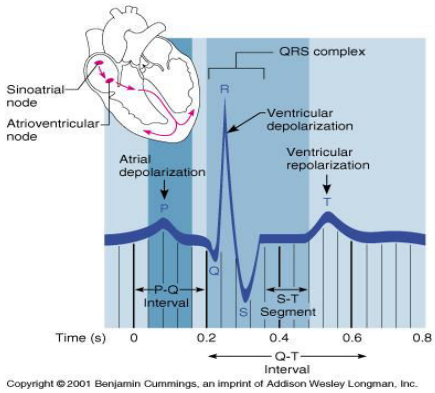
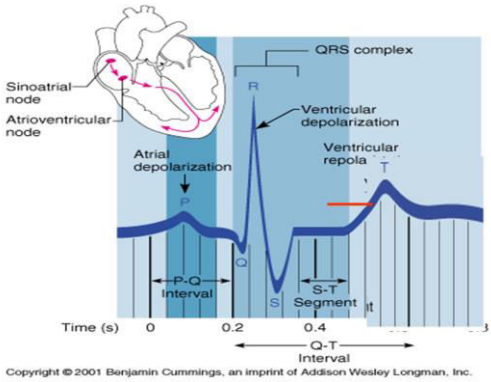
- ✓ When the SA node (the pacemaker) depolarizes , the wave of depolarization that sweeps through the atria is recorded as the P wave.
- ✓ The Q, R, and S waves occur in rapid succession, do not all appear in all leads, and reflect a single event, and thus are usually considered together. The QRS complex is caused by depolarization of the ventricles. Hidden in the QRS complex is the repolarization of the atria since that occurs while the ventricles are depolarizing.
- ✓ A Q wave is any downward deflection after the P wave.
- ✓ An R wave follows as an upward deflection.
- ✓ The S wave is any downward deflection after the R wave.
- ✓ The T wave follows the S wave .The T wave represents repolarization of the ventricles. An important information related to T wave you have to know:

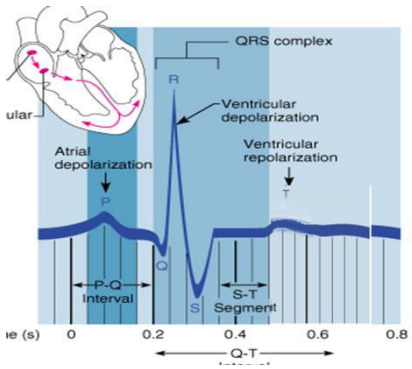
- Mainly **K+ concentration in blood affects the T wave** and according to that We have 2 conditions related to this:
  1) An **elevated T wave** is indicative of **hyperkalemia**, a condition which if not corrected may become life threatening.
  2) **A flat T wave** is indicative of **hypokalemia** or sometimes **ischemia**.



Normal T wave



Elevated T wave



Flattened T wave

❖ Arrhythmias

- causes of cardiac arrhythmias:

- ✓ **Abnormal rhythmicity of the pacemaker.**
- ✓ **Shift of pacemaker from sinus node (ectopic pacemaker).**

- ✓ **Blocks at different points in the transmission of the cardiac impulse (AV blocks).**
- ✓ **Abnormal pathways of transmission in the heart (right and left bundle branch block).**
- ✓ **Spontaneous generation of abnormal impulses from any part of the heart.**

Abnormal heart rhythms include 2 conditions :

1. Tachycardia
2. Bradycardia

First: Tachycardia

- Tachycardia means a **fast heart rate** usually **greater than 100 beats /min** (**R-R interval is less than 0.6** second).
- Caused by (1) **increased body temperature in case of fever, (2) sympathetic stimulation (such as from loss of blood and the reflex stimulation of the heart), and (3) toxic conditions of the heart.**
- Tachycardia could be **sinus tachycardia** or **ventricular tachycardia**

Sinus	Ventricular
SA node is depolarizing faster than normal, impulse is conducted normally.	Ectopic pacemaker discharging very high heart rate
Every P wave is followed by QRS complex	***Not** every P wave is followed by QRS complex rather they aren't related to each other.*
sinus tachycardia is a response to physical or psychological stress, not a primary arrhythmia	

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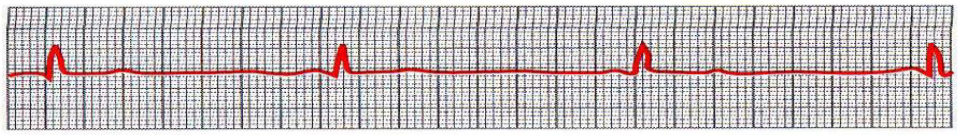
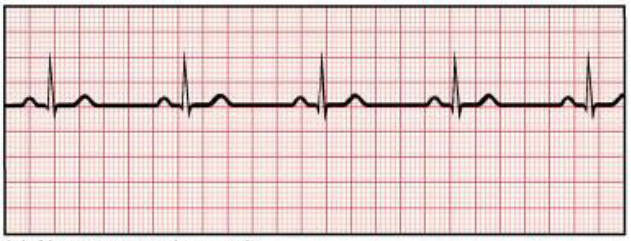
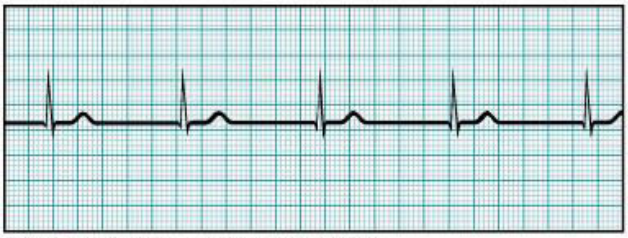
⌘ Second: Bradycardia



- Bradycardia means **slow heart rate** usually **less than 60 beats /minute** (**R-R interval** is **more than 1** second)
- **Caused by (1) decreased body temperature, (2) parasympathetic stimulation , vagal stimulation, one example of which is the carotid sinus syndrome (Adams-Stokes Syndrome)**
- **Present in athletes who have a large stroke volume**
- **Sinus bradycardia :**
  - SA node is depolarizing slower than normal, impulse is conducted normally (i.e. normal PR and QRS interval) .
  - In sinus bradycardia each P wave is followed by QRS complex.
  - Sinus bradycardia doesn't mean AV block because in AV block PR interval is longer than 0.2 second while in sinus bradycardia it is normal.

❖Sinoatrial block


(a) Sinus rhythm (normal)


(b) Nodal rhythm – no SA node activity

- ✓ In rare instances impulses from S-A node are blocked.
- ✓ This causes cessation of P waves.
- ✓ New pacemaker is a region of heart with the fastest discharge rate, usually the A-V node.
- ✓ Now look at the picture on the right. In part (b) of the picture where there is **no SA node activity** you can see that there is **no P waves.** Remember that P wave is a result of atrial depolarization and when there is no SA node, no depolarization of atria occurs and no p waves appear. This is a condition known as **Atrial fibrillation**.
- ✓ Atrial fibrillation is **not dangerous** and patients with this condition can live normal life because atrial systole isn't that important to the function of the heart (this will be discussed in next lectures). On the contrary, **Ventricular fibrillation is a lethal condition**.

❖Atrioventricular block (heart blocks)

- ✓ In atrioventricular block Impulses through A-V node and A-V bundle (bundle of His) are slowed down or blocked due to :

  (1) Ischemia of A-V nodal or A-V bundle fibers (can be caused by coronary ischemia)

  (2) Compression of A-V bundle (by scar tissue or calcified tissue or tumor)

  (3) A-V nodal or A-V bundle inflammation

  (4) Excessive vagal stimulation causes the heart to stop then the heart resumes its contraction by the rate of Purkinje fibers and this is known as overdrive suppression and ventricular escape.

- ✓ Heart blocks are of three degrees. First and second degrees are called **incomplete** heart block while third degree is called **complete** heart block. Each degree will be discussed separately.

⌘First degree heart block

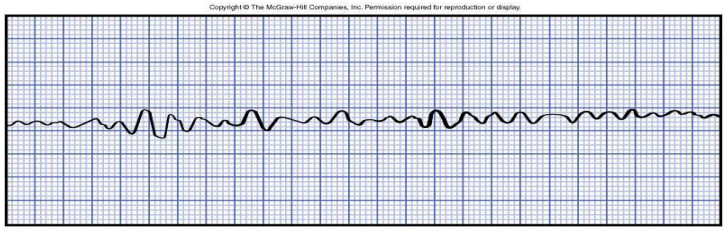
- ✓ Etiology: Prolonged conduction delay in the AV node or Bundle of His.
- ✓ If **P-R interval is > 0.2** sec, first degree block is present (but P-R interval seldom increases above 0.35 to 0.45 sec).
- ✓ Each P wave is followed by QRS complex.

⌘Second degree heart block

- ✓ Etiology: Each successive atrial impulse encounters a longer and longer delay in the AV node until one impulse (usually the 3rd or 4th) fails to make it through the AV node.
- ✓ **P-R interval is > 0.2 and increases to 0.25 - 0.45 sec**
- ✓ Some impulses pass through the A-V node and some do not thus causing **"dropped beats" or " palpitations".**

- ✓ There will be missed QRS complexes (some P waves followed by QRS and some aren't). The absence of QRS means there is no systole of the ventricles resulting in **ventricular fibrillation**. If QRS complexes appear as saw shape then ventricular fibrillation is present and you have to *de-fibrillate* the patient by *D.C shock*.
- ✓ Atria beat faster than ventricles. This is because When you count P waves (atrial depolarization) you will find them larger in number than QRS (ventricular depolarization). **Usually in second degree heart block the ratio of P to QRS is equal to 2: 1 (regular irregularity).**

- ✓ In case of VF no pumping action is present.



(e) Ventricular fibrillation

⌘Third degree heart block

- ✓ Etiology: There is complete block of conduction in the AV junction, so the atria and ventricles form impulses independently of each other. Without impulses from the atria, the ventricles own intrinsic pacemaker beats (Purkinje) at around 15 - 40 beats/minute which means **HR will be less than 40**.
- ✓ P waves are completely dissociated from QRS complexes.
- ✓ Ventricles escape and A-V nodal rhythm ensues

❖Stokes-Adams Syndrome

- ✓ Caused by Complete A-V block that comes and goes.
- ✓ Ventricles stop contracting for 15-30 seconds because of overdrive suppression meaning they are used to atrial drive.
- ✓ Patient faints because of poor cerebral blood flow and then wake up because ventricular escape occurs with a rhythm of (15-40 beats /min).
- ✓ A Patient with complete heart block need Artificial pacemaker because it is hard for human to live with 15-40 heart rate. The pacemaker is inserted in the right ventricle. Impulses are sent from

right to left ventricle via ventricular muscles. The battery of this pacemaker is planted under the skin and it is changed periodically. (THe pacemaker is placed in the antecubital vein, then it passes along the axillary vein to the brachiocephalic vein and superior vena cava, to the right atrium, and finally inserted in the right ventricle).

❖Factors Causing Electrical Axis deviation

- ✓ **Left axis deviation** may occur **normally** in people who are **short and obese.**
- ✓ **Right axis deviation** may occur **normally** in people who are **tall and thin.**
- ✓ **Left axis deviation** in case of **Hypertrophy of left ventricle** caused by *hypertension, aortic stenosis or aortic regurgitation*. Causes slightly prolonged (wide) QRS and high voltage.
- ✓ **Right axis deviation** in case of **Hypertrophy of right ventricle** caused by *pulmonary hypertension, pulmonary valve stenosis or interventricular septal defect.* All cause slightly prolonged (wide) QRS and high voltage.
- ✓ **Left bundle branch block** causes **left axis deviation** because right ventricle depolarizes much faster than left ventricle.
- ✓ **Right bundle branch block** causes **right axis deviation.**
- ✓ To differentiate between hypertension and right or left bundle branch block, in case of the right or left bundle branch block **QRS complex is very wide .**
- ✓ To differentiate between right and left bundle branch block you look at the axis deviation:
  - * If the axis is deviated to the right then it is right bundle branch block.
  - * If the axis is deviated to the left then it is left bundle branch block.

"لا تُسلِّم عقلك لأحد، لا تسمح لأحد بالتفكير بالنيابة عنك، لا تُمرر الخارج إلى داخلِك بدون فلترة ، لا تترك عقلك بكرتونته، وستكون بخير! "

هذه الشيت مهداة بشكل خاص لأختي الرقيقة سلسبيلا بني حمد ♥ و أخواتي : ياسمين خاطر، نور حماد، رزان الرواشدة، دانيا قرنفلة، و المعلمة الأجمل على الإطلاق أماني الحلبي و ثلاثي الجنون الأروع (ألف.سين.غين)