ECG summary

Side notes :

1. **There is no potential is recorded when the ventricular muscle is either completely depolarized or repolarized. (isoelectric)**
2. **During each cycle (each beat), we record depolarization of the atria, then depolarization of the ventricles then ventricular repolarization.**
3. **Normal ECG is PQRST, and the repetition of this recording is called the cardiac cycle**
4. **There should be an atrial repolarization,** but this occurs during the ventricular depolarization, so it is masked and doesn't show up.
5. **The ventricular repolarization is an upward deflection although it is a repolarization since** it occurs from the pericardium to the endocardium.
6. **T wave and QRS are upward deflections, because:**
   - Depolarization —> from endocardium to pericardium – from the base of the heart to the apex.
   - Repolarization —> from pericardium to endocardium - from the apex of the heart to the base.

Electrocardiogram

-To have a mechanical change , there must be electrical change first .

- the direction of depolarization (vector) it is from right to left and anterior, in other words, it is directed downward to the left.

Atrial contraction ← | → V. contraction

P-wave	QRS complex	T- wave
Atrial depolarization	Ventricular depolarization	Ventricular repolarization

-PR interval :

*extends from start of atrial depolarization to start of ventricular depolarization

*Can indicate damage to conducting pathway or AV node if greater than 0.2 second [normal value 0.16 sec]

• Segments are normally on the isoelectric line so : deflections in these segments (whether up or down) indicate abnormality

-QT interval :

-time required for ventricle depolarization and repolarization [normal value : 0.35 sec]

-this time = half time of cardiac cycle

-can be lengthened by electrocyte disturbance, conduction problems, myocardial damage

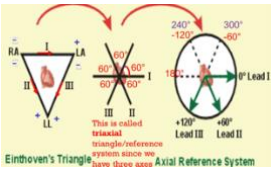
***S-T Segment** is significant to indicate ischemia of the heart if was deflected upward or downward (normally segments must be on the isoelectric line)

• Ventricular depolarization starts at the ventricular septum and the endocardial surfaces of the heart, so the wave of depolarization is from the endocardium toward the epicardium.

• The average current flows positively from the base of the heart to the apex.

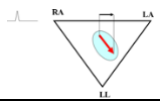
• At the very end of depolarization the current reverses from 1/100 second and flows toward the outer walls of the ventricles near the base (S wave)
● The normal mean QRS vector is 60o (-30◦ - +110◦)
● Remember: Clinicians use the range (0◦ - 90◦)

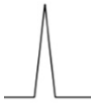
EKG Concepts:
• The ventricles remain contracted until a few milliseconds after the end of the T repolarization wave.
• The atria remain contracted until the atria are repolarized, but an atrial repolarization wave cannot be seen on the electrocardiogram because it is masked by the QRS wave.
• The heart rate can be determined with the reciprocal of the time interval between each heartbeat, and **the heart rate is inversely proportional to the time of heartbeat**.

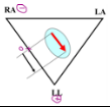


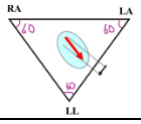
Bipolar Limb Leads

• Bipolar means that the EKG is recorded from two electrodes on the body.

Lead 1	is between right arm (negative electrode) & left arm (positive electrode). 

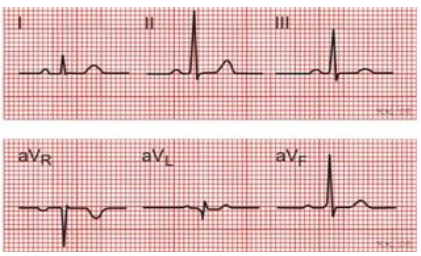


Lead 2	is between right arm (negative electrode) & left leg(positive electrode). 

Lead 3	is between left arm (negative electrode) & left leg (positive electrode). 

Augmented Unipolar Limb Leads

X	(+) elecrode	(-) electrode
aVR	Rt arm	Lt arm + left leg
aVL	Lt arm	Rt arm + left leg
aVF	Left foot	Rt arm + Lt arm



aVR case :

• The right arm here is positive so if the direction of the mean electrical axis is to that side it would be positive, and to the other side (both sides) it is negative, but as we can see it is a negative recording

(mean electrical axis above is going away from the positive electrode)

• This is because the direction of the mean electrical axis is going **to record positive** if it is **going towards** the positive electrode and if it is **going away** from the positive electrode it is going to record a **negative recording**.

aVL case :

• mean electrical axis is going towards the positive electrode, **small positive recording**

• It is going to be very high in the case of aVF.

In aVF:

the mean electrical axis is going to the positive electrode, so it is going to be a very **high positive recording**

Chest Leads (Precordial Leads) known as V1-V6

These leads show the electrical changes on the anterior aspects of the heart.

Mean electrical axis is:

• Going away from the positive electrode in **V1 and V2** **(negative recording)**

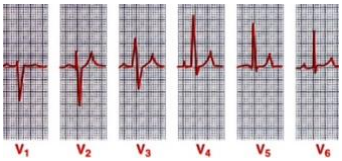
• Going towards **V3** then away from it **(almost zero recording**)

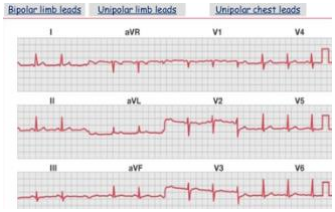
• In other words, V3 is placed midway of the mean electrical axis

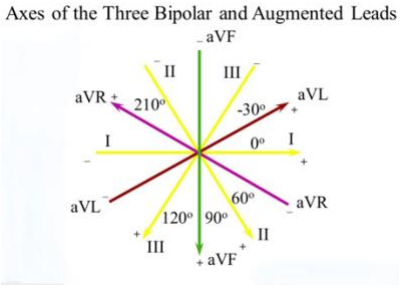
• Going towards the positive electrode in **V4, V5, V6** **(positive recording**)

What if we want to check the posterior aspect of the heart?

• Use the esophagus.







Each lead has a perpendicular one:

1. Lead1 & aVF (important). 2. Lead2 & aVL. 3. Lead3 & aVR

● **The axis of lead I is zero degrees** because the electrodes lie in the horizontal direction on each of the arms.

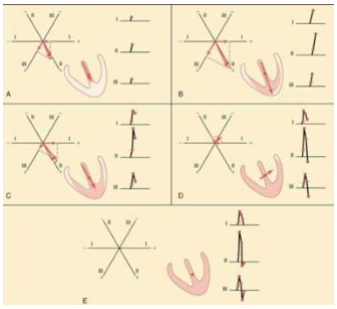
● **The axis of lead II is +60 degrees** because the right arm connects to the torso in the top right corner, and left leg connects to the torso in the bottom left corner.

● **The axis of lead III is 120 degrees**

Using ECG recordings to determine MEA angle	
ECG result	**Interpretation**
QRS (Lead 1) → + QRS (aVF) → +	Angle is between 0° and 90° (Normal)
Lead 1 → + aVF → -	Angle is between -90° and 0° (Left axis deviation)
Lead 1 → - aVF → +	Angle is between 90° and 180° (Right axis deviation)
Lead 1 → - aVF → -	Angle is between -90° and -180° (Extreme right axis deviation)

Lecture 6

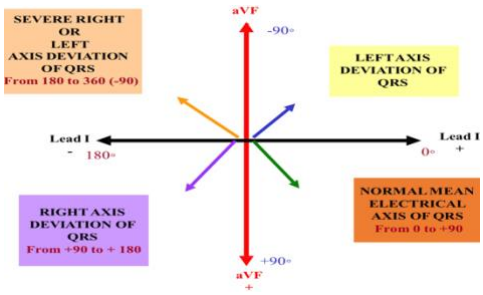
- In figure B, the depolarization vector is **large because half of the ventricle is depolarized**.
- Lead II should be largest voltage when compared to I and III when the mean vector is 60o.
- In figure C, left side is slower to depolarize.
- In figure D, the **last part to depolarize** is near the left base of the heart which gives a **negative vector** **(S wave)**
- Q wave is present if the left side of the septum depolarizes first. **(negative recording**)
- E: Represents the heart when it is completely depolarized, so here there's no potential difference **(zero reference point**)



The T Wave (Ventricular Repolarization)	**Atrial Depolarization (P-Wave) and Atrial Repolarization (Atrial T Wave)**
• First area to repolarize is near the apex of the heart. • **Last areas to depolarize are the first to repolarize**. • Repolarized areas will have **a + charge** first , a + net vector occurs and a ***positive T wave is recorded***.	• **Atrial depolarization** begins at sinus node and spreads toward A-V node • ***This should give a + vector in leads I, II, and III*** • **Atrial depolarization is slower than in ventricles**, so **first area to depolarize is also the first to repolarize** >> This gives a ***negative atrial repolarization wave in leads I, II, and III***.

Determining Mean Electrical Axis:

Measure the sum of the height and the negative depth of QRS complex



Cardiac abnormalities

Causes of Cardiac Arrythmias:

1. Abnormal rhythmicity of the pacemaker (The same pacemaker but it's abnormal)
2. Shift of pacemaker from sinus node (we call it an ectopic pacemaker)
3. Blocks at different points in the transmission of the cardiac impulse
4. Abnormal pathways of transmission in the heart
5. Spontaneous generation of abnormal impulses from any part of the heart

Abnormal Sinus Rhythms

Tachycardia	Bradycardia
means a fast heart rate usually greater than **100** bm. **Caused by** (1) increased body temperature (2) sympathetic stimulation	• slow heart rate usually less than **60** beats/min • Present in **athletes** who have a large stroke volume **Cardiac output (CO) = stroke volume (SV) * heart rate (HR**)

(3) toxic conditions 1) hyperthyroidism , 2) Hypercalcemia, 3) Hypokalemia **increase in heart rate >> increases in cardiac output. In severe tachycardia, the filling time is very short; leading to low cardiac outputs**.	• Since athletes have a high stroke volume, and for them to have a normal cardiac output, they have a lower heart rate • Can be caused by **vagal stimulation**, one example of which is the carotid sinus syndrome **(pressure on the carotid sinus = Stokes-Adams syndrome)**
Sinus Tachycardia : due to stress • All waves (PQRST) are normal • But their rate (the number of cycles is abnormal) Etiology: SA node is depolarizing faster than normal, impulse is conducted normally.	**Sinus Bradycardia** • SA node is depolarizing slower than normal, impulse is conducted normally (i.e. normal PR and QRS interval) rate is slower than 60/beats per minute

Sinoatrial Block	Atrioventricular Block
• impulses from S-A node are blocked. • no P wave • the heart rate will be between 40 to 60 per minute which is the rate of the AV node	• PR interval >0.3 seconds • 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 (2) Compression of A-V bundle or inflammation (3) Excessive vagal stimulation (Stokes-Adams syndrome)

There are 3 degrees of AV blocks:

1st Degree : Incomplete Block	**-each P is followed by QRS** **-Etiology:** Prolonged conduction delay due to damage in the AV node -2 large squares in a PR interval
2nd Degree: InComplete Block	**- not all are followed with QRS.** **-Some impulses pass through the A-V node (will have QRS), and some do not (will not have a QRS) thus causing "dropped beats" (the patients feel palpitation)** **Etiology:** **- Each successive atrial impulse encounters a longer and longer delay in the AV node until one impulse** **-There is an abnormality in the AV node; sometimes it permits the conduction, sometimes it doesn't.**
3rd Degree: Complete Block	**-P waves are completely dissociated from QRST complexes** **-there is no association between Ps and QRSs, they're completely dissociated** **-The heart rate is below 40 beat per minute, because the heart rate is from Purkinje fibers** **-Ventricles escape (because the ventricles are not affected by the Vagus nerve)** **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**

- **Stokes-Adams Syndrome**

• There is a pressure from the carotid sinus on the Vagus nerve which is becoming extremely stimulated, this will decrease the heart rate and the SA node might be suppressed —> heart to stop beating, but it starts beating after 15 to 30 seconds because the purkinje resumes its own rate (15 to 40).
Why does that occur after 15-30 seconds and not right away? because this is a biological system and it does not resume its activity right away, it needs time to start.

- **Complete A-V block comes and goes.**
- **Ventricles stop contracting for 5-30 sec because of overdrive suppression meaning they are used to atrial drive.**
- **Patient faints because of poor cerebral blood flow**
- **Then, ventricular escape occurs with A-V nodal or A-V bundle rhythm (15-40 bm)**

Factors Causing Electrical Axis deviation
Changes in heart position:
Left shift caused by expiration,lying down and excess abdominal fat , short and obese

Right shift caused by thin and tall person

***Hypertrophy of left ventricle (left axis shift) caused by:**

1. Arterial Hypertension: the heart must develop too much pressure against the pressure in the aorta --> depolarization takes longer time.
2.aortic stenosis : the left ventricle must develop a lot of pressure to pump that small amount in the narrow orifice of the valve so hypertrophy occurs, and this hypertrophy will cause left axis deviation
3. aortic regurgitation
Hypertrophy causes slightly prolonged QRS and high voltage

Hypertrophy of right ventricle (right axis shift) caused by: All cause slightly prolonged QRS and high voltage

1.pulmonary hypertension,pulmonary valve stenosis

2.pulmonary regurgitation, inter ventricular septal defect (VSD)

ECG Deflection Wave Irregularities

Enlarged QRS: Hypertrophy of ventricles
Prolonged QT Interval: Repolarization abnormalities increase chances of ventricular arrhythmias(inverted T-wave)
Elevated T wave: Hyperkalemia
Flat T wave (depressed) :Hypokalemia or ischemia

Increased Voltages in Standard Bipolar Limb Leads

- If sum of voltages of Leads I-III is **greater than 4 mV**, this is considered to be a high voltage EKG.
- **Ventricular hypertrophy** (hypertension, marathon runner).

Decreased Voltages in Standard Bipolar Limb Leads

- **Cardiac muscle abnormalities**

(old infarcts causing decreased muscle mass (infarction, valvular disease , low voltage EKG, and prolonged QRS)

Decreased voltage --> **can happen in obese patients, cardiac tamponade, fluid in pericardium (pericardial effusion), pleural effusion or emphysema (in chronic smokers, the septa between alveoli is defect).**