PHYSIOLOGY

بسم الله الرحمن الرحيم

MID | Lecture 5

Electrocardio-graghy (Pt.2)

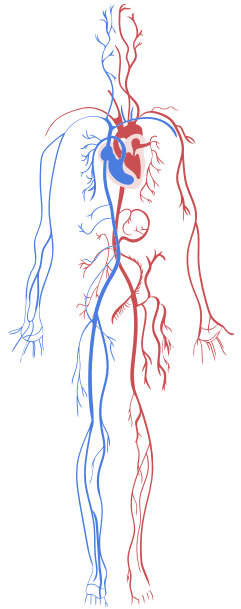
وَلَقَدْ خَلَقْنَا الْإِنسَانَ وَنَعْلَمُ مَا تُوَسْوِسُ بِهِ نَفْسُهُ ۖ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ حَبْلِ الْوَرِيدِ

اللهم إنّا نعوذ بك من شرور أنفسنا ومن سيئات أعمالنا

Written by: Hala Swiedan

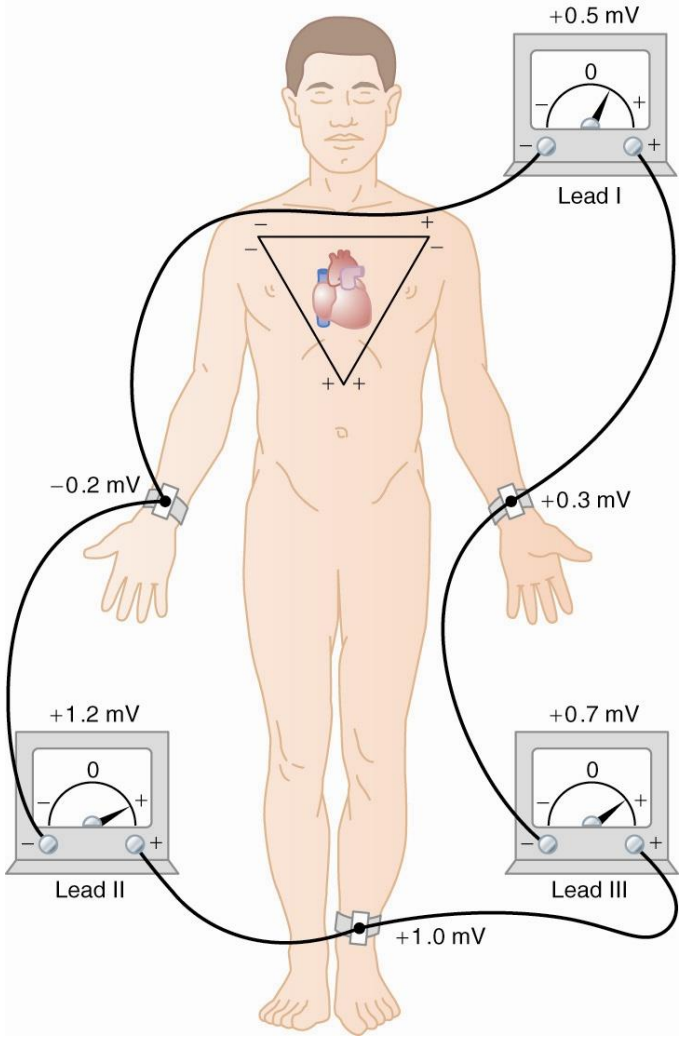
Hala Al-Turman

Reviewed by: Sadeel Al-hawawsheh



Bipolar Limb Leads

- Bipolar means that the EKG is recorded from tow electrodes on the body. **Bipolar Limb Leads**
- The term **bipolar** means that the ECG is measured using **two electrodes**, where:
    - One electrode serves as the **negative pole**, and
    - The other serves as the **positive pole**.
- There are **three bipolar limb leads** in a standard electrocardiogram (ECG or EKG): **Leads I, II, and III**.
- Each of these leads records the **electrical potential difference** between **two electrodes** placed on the body — one **positive** and one **negative**.
- Because each lead uses **two poles**, they are called **bipolar** leads.



Bipolar Limb Leads (cont'd)

- Lead I - The **negative** terminal of the electrocardiogram is connected to the **right arm,** and the **positive** terminal is connected to the **left arm**.

- Lead II - The **negative** terminal of the electrocardiogram is connected to the **right arm**, and the **positive** terminal is connected to the **left leg.**

- Lead III - The **negative** terminal of the electrocardiogram is connected to the **left arm**, and the **positive** terminal is connected to the **left leg.**

- **Why Electrodes Are Placed This Way?**
  - Einthoven, a German physiologist, arranged the limb electrodes in specific positions to produce **positive recordings** in all three **bipolar leads**.
- The term **EKG** comes from the German *"Elektrokardiogramm"* — in German, "cardiology" is spelled with a **K**, so **ECG** and **EKG** mean the same thing.

Bipolar Limb Leads (cont'd)

- Einthoven's Law states that the electrical potential of any limb equals the sum of the other two (+ and - signs of leads must be observed). L II= L I + L III
- If lead I = 1.0 mV, Lead III = 0.5 mV, then Lead II = 1.0 + 0.5 = 1.5 mV
- Kirchoff's second law of electrical circuits. LI+LII+LIII=0

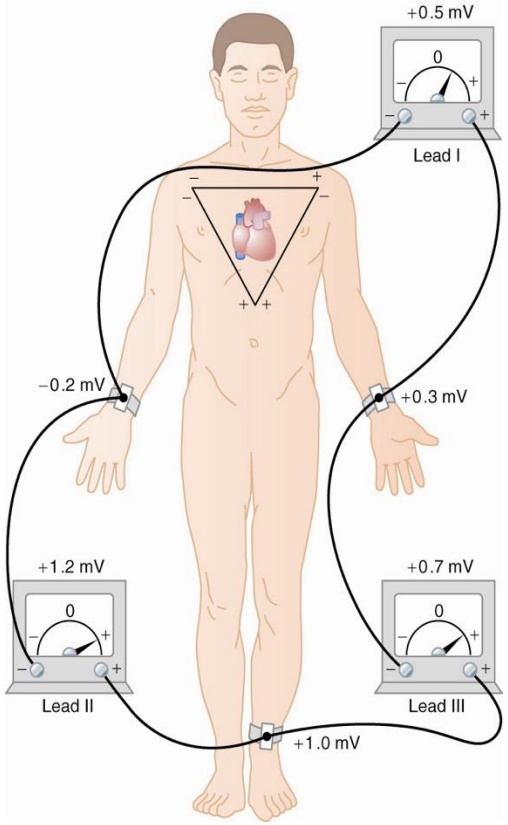
Please see the next slides

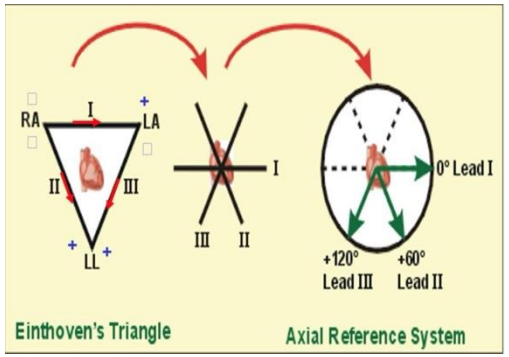
Bipolar Limb Leads (cont'd)

Einthoven's Law and triangle

- Einthoven's Law states that "In a standard limb-lead ECG, the potential in Lead II is equal to the sum of the potentials in Leads I and III", or simply: **Lead II = Lead I + Lead III**.
- For example, in the image, Lead I records **+0.5** and Lead III records **+0.7**, their sum is **+1.2**. Einthoven explained that the heart is located approximately at thr centre of these limb leads, which can be represented as an **equilateral triangle**, where all angles are equal to 60°. This geometric representation helps illustrate the direction of the electrical current as vectors.
- The electrical current flows from the negative pole to the positive pole, and it can be represented as a **vector**, with **magnitude (value) and direction**. Each lead points from its negative to its positive electrode. When vectors of Lead I and Lead III are combined, the **resultant vector points in the direction of Lead II**. In simple term, each lead can acts like an arrow, and adding the arrows of lead I and III gives the arrow oflead II . This is the essence of **Einthoven's Law**:

  Lead I + Lead III = Lead II.





Bipolar Limb Leads (cont'd)

Kirchhoff's Second Law of Electrical Circuits

- Kirchhoff stated that in any **closed** electrical circuit, the **sum of all voltage changes (vectors)** equals **zero**.
- When applied to the limb leads, if we take the vectors of Lead I and Lead III, and reverse the direction of Lead II, their total sum equals zero: **Lead I + Lead III – Lead II = 0**

- **Why Einthoven's and Kirchhoff's Laws matter for the heart?**

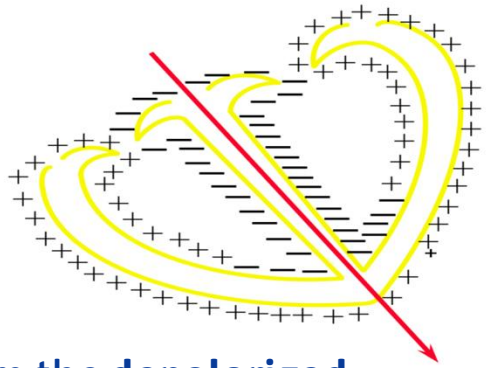
  The heart produces electrical currents that spread throughout the body and can be measured on the skin.

  - **Einthoven's Law (Lead II = Lead I + Lead III) shows how the heart's electrical activity can be represented geometrically as vectors within an equilateral triangle.**
  - **Kirchhoff's Law (the sum of voltages in a closed loop = 0) provides the mathematical basis for why these vector relationships among the leads are consistent.**

  Bottom line: Together, these laws make it possible to measure, analyze, and interpret the heart's electrical activity accurately using the ECG.

Mean Vector Through the Partially Depolarized Heart

The **QRS complex** on the ECG represents the **depolarization of the ventricles**. This electrical activation begins in the **interventricular septum** and spreads through the ventricles in the following sequence:



1. **Septum** – from **left to right**
2. **Anterior walls** of the ventricles
3. **Apex** of the heart
4. **Lateral walls** of the ventricles
5. **Posterior walls** of the ventricles

During this process, as each small area of the ventricles depolarizes, an **electrical current** flows from the **depolarized region** toward the **regions that are still polarized**. At any given moment, these currents exist in many directions throughout the ventricular walls.

These currents can be represented as **vectors**. By summing all the small vectors occurring at a particular instant, we obtain a **resultant vector** (shown as the red arrow). When ventricular depolarization is complete, the sum of all these vectors forms the **mean electrical vector** of the QRS complex – the overall direction of ventricular activation.

Under normal conditions, this mean electrical vector points **to the left and anteriorly**. However, in conditions like **dextrocardia** (where the heart lies on the right side of the chest), the mean vector may shift **anteriorly and to the right**.

The **QRS complex** visually reflects how electrical activation spreads through the ventricles, while the **mean electrical vector** represents the **overall direction of depolarization** in the heart.

ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

The **red arrow (in the next three slides)** represents the **mean electrical vector** of the heart, which points **to the left and anteriorly**. This mean vector can be analyzed along the directions of **Leads I, II, and III**. The **three standard limb leads** (I, II, and III) form an **equilateral triangle**, with each side representing the electrical axis of a lead.

The **center of the triangle** corresponds to the **electrical center of the heart**. If perpendicular lines are drawn from the center to each side, they **bisect the triangle's sides**, allowing the projection of the mean vector onto each lead direction.

To find the component of the **mean electrical vector (mean QRS vector)** along any lead:

1. Draw the **vector** representing the mean electrical axis.
2. Drop **perpendiculars** from the tip of the vector onto the sides representing **Leads I, II, and III**.
3. Each perpendicular line corresponds to the **magnitude of the projection** of that vector on the respective lead.

In other words, the height of each perpendicular indicates how strongly the mean vector is expressed in that lead.

Since an ECG records the **voltages (amplitudes)** for **Leads I, II, and III**, we can use any **two leads** (to be disscused) to **calculate the mean electrical axis retrospectively**. When plotting these leads so that they meet at a single central point with **60° angles between them**, their vector relationship allows us to determine:

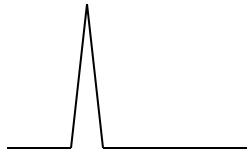
- The **direction (angle)** of the mean QRS vector.
- The **magnitude** of the vector (overall electrical force).

ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

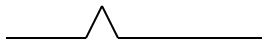
3 Bipolar Limb Leads:

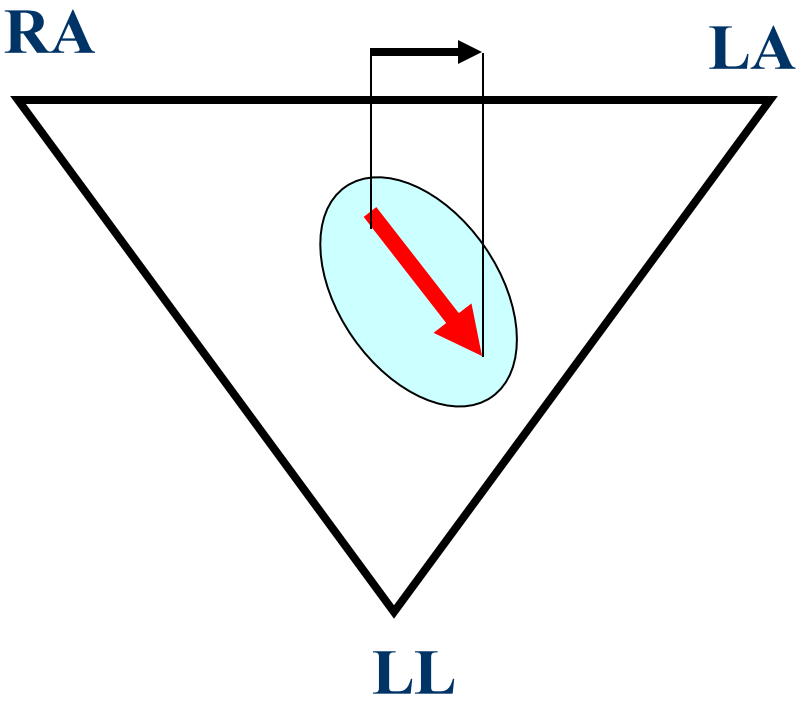
I = RA vs. LA (+)

II = RA vs. LL (+)



III = LA vs. LL (+)





ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

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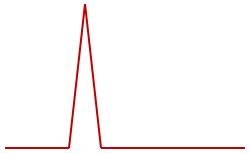
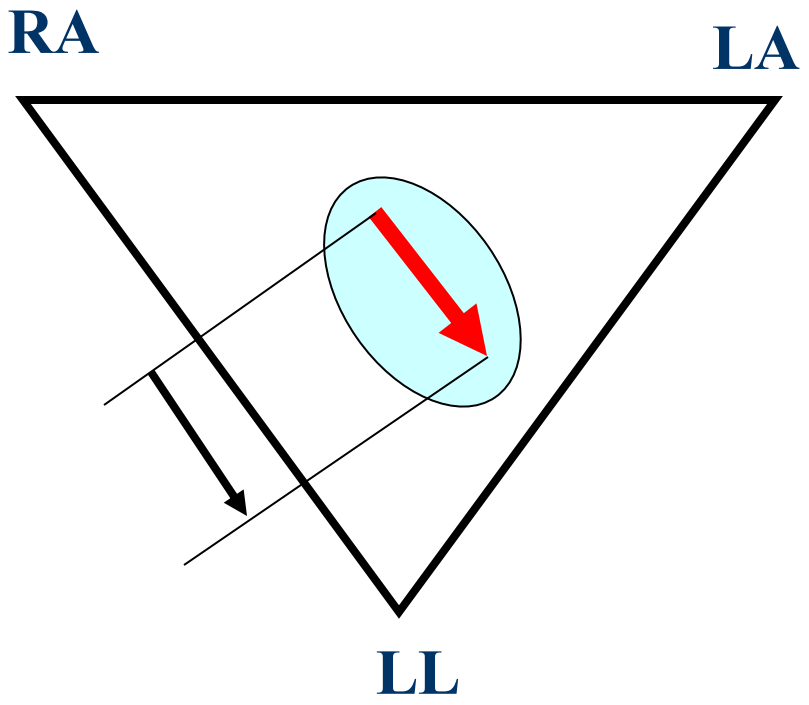


III = LA vs. LL (+)



ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

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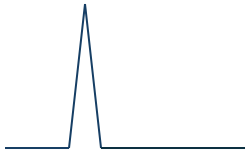
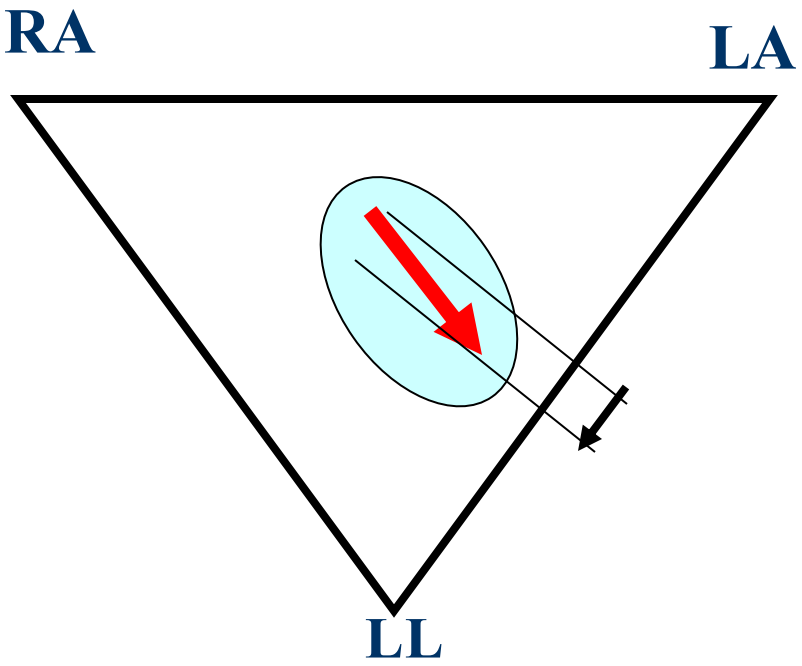
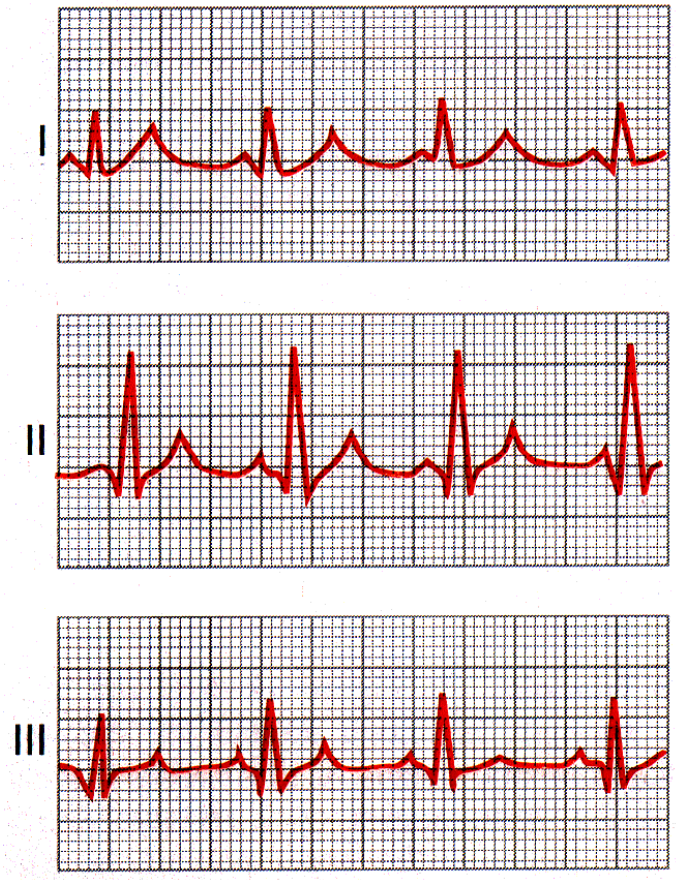


III = LA vs. LL (+)



Bipolar Limb Leads (cont'd)



QRS values

0.5 mV

1.2 mV

0.7 mV

Lead II is the best and easiest to use:

- It is **best** because it aligns with the **natural direction of ventricular depolarization**, giving the **largest QRS amplitude**.
- It is **easiest** because the waves (P, QRS, T) are **clearly visible**

Other EKG Leads (cont'd)

- Augmented Unipolar Limb Leads aVR, aVL, and aVF are also in use.

- For aVR the + electrode is the right arm, and the - electrode is the left arm + left leg

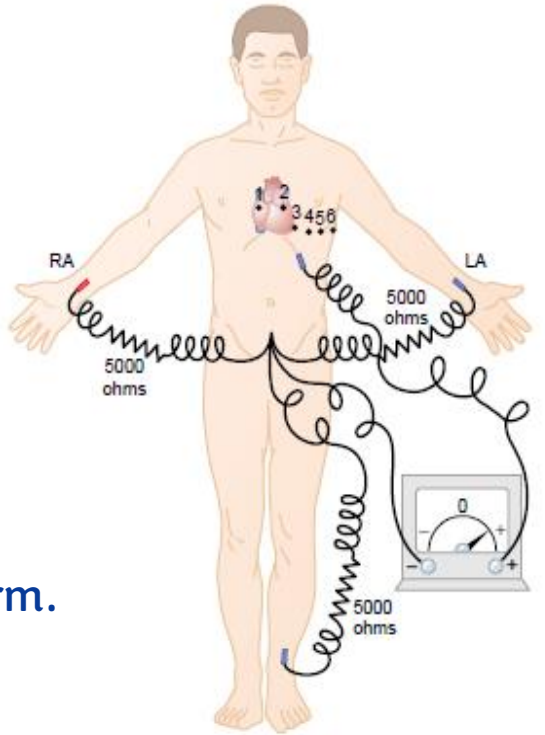
- For aVL + electrode is left arm; aVF + electrode is left foot and the negative electrode is the other two limbs

Please see the next slides

Unipolar Limb Leads

After the development of **bipolar limb leads**, scientists aimed to **record the heart's electrical activity** relative to a central reference point considered to be at **zero electrical potential**. This "zero point" represents the **electrical center of the heart,** where the depolarized and polarized regions cancel each other out.

Wilson introduced the **first unipolar limb leads**. He created a central reference called the **Wilson Central Terminal (WCT)** by connecting the right arm, left arm, and left leg through equal high resistances (about 5,000 ohms each). Because of these high resistances, almost no current flows, and the combined point acts as a **neutral reference** close to the heart's electrical center.



With this setup, the positive electrode can be placed on different limbs to record voltage relative to this central point:

- **Right arm:** produces **VR**, representing the voltage from the heart center to the right arm.
- **Left arm:** produces **VL**, representing the voltage from the heart center to the left arm.
- **Left leg:** produces **VF**, representing the voltage from the heart center to the left leg.

In this system, each lead measures the **electrical activity between the heart's center and a single limb**, allowing more comprehensive recording of cardiac electrical activity compared to the bipolar leads.

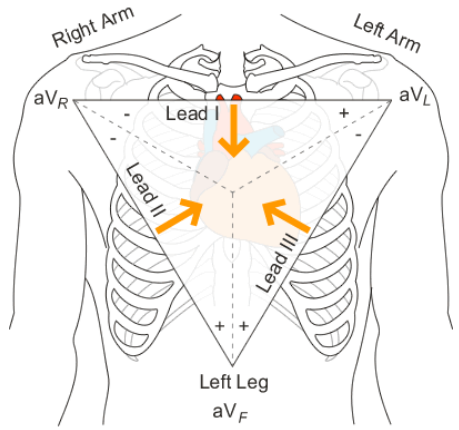
This may slightly conflict with what the professor mentioned in the lecture, but this version is the more accurate one

Unipolar Limb Leads

Goldberger's Improvement: Augmented Limb Leads

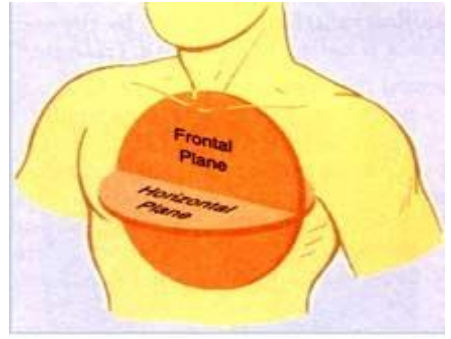
Wilson's original unipolar leads produced low-amplitude signals because the exploring electrode contributed to the reference terminal. To strengthen these signals, Goldberger modified Wilson's design:

- He removed the exploring limb from the reference circuit.
- The reference point became the average of only the other two limbs instead of all three.
- This increased the amplitude by 50%, so the leads are called augmented.



This produced the three augmented limb leads:

- **Right arm recording:** Goldberger removed the resistance from the right arm and connected the **positive electrode directly** to it. This increased the voltage, which he called **aVR** (augmented Vector Right arm).
- **Left arm recording:** He connected high resistances to the right arm and left leg, using the **left arm as the positive electrode**, producing **aVL** (augmented Vector Left arm).
- **Left foot recording:** He connected high resistances to the right and left arms, using the **left foot as the positive electrode**, producing **aVF** (augmented Vector Foot)



After this improvement, there are **six limb leads** in total:

- **Three bipolar leads:** Lead I, Lead II, Lead III
- **Three unipolar augmented leads:** aVR, aVL, aVF

All six leads record the **heart's electrical activity in the frontal plane**, providing multiple angles to analyze the heart's mean electrical vector.

This may slightly conflict with what the professor mentioned in the lecture, but this version is the more accurate one

ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

ECG Deflections and the Mean Electrical Axis
The deflection recorded on an electrocardiogram (ECG) depends on the direction of the heart's electrical activity relative to the lead's positive electrode.

Depolarization

- When the **wave of depolarization** moves **toward** the **positive electrode**, the ECG records a **positive (upward) deflection**.
- When the **wave of depolarization** moves **away from** the **positive electrode**, a **negative (downward) deflection** is recorded.

Repolarization

- When the **wave of repolarization** moves **toward** the **positive electrode**, it produces a **negative deflection**.
- When the **wave of repolarization** moves **away** from the **positive electrode**, it produces a **positive deflection**.

Behavior in Augmented Limb Leads (PLEASE SEE THE NEXT THREE SLIDES)

- **aVR:** Positive electrode on the **right arm** → the mean depolarization vector moves **away**, so it shows a **negative deflection**.
- **aVL:** Positive electrode on the **left arm** → the mean vector moves **partly toward** it, giving a **small positive deflection**.
- **aVF:** Positive electrode on the **left foot** → the mean vector points **mostly toward** it, giving the **largest positive deflection** among the augmented leads.

Behavior in Bipolar Limb Leads (PLEASE SEE SLIDE 21)

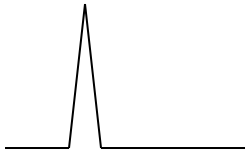
- **Lead II** shows the **largest positive deflection** because its orientation (from right arm to left leg) is **most parallel** to the mean electrical vector.
- **Lead I** shows a smaller positive deflection, as it is **less aligned** with the mean vector.
- **Lead III** shows an intermediate deflection depending on the heart's electrical axis.

ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

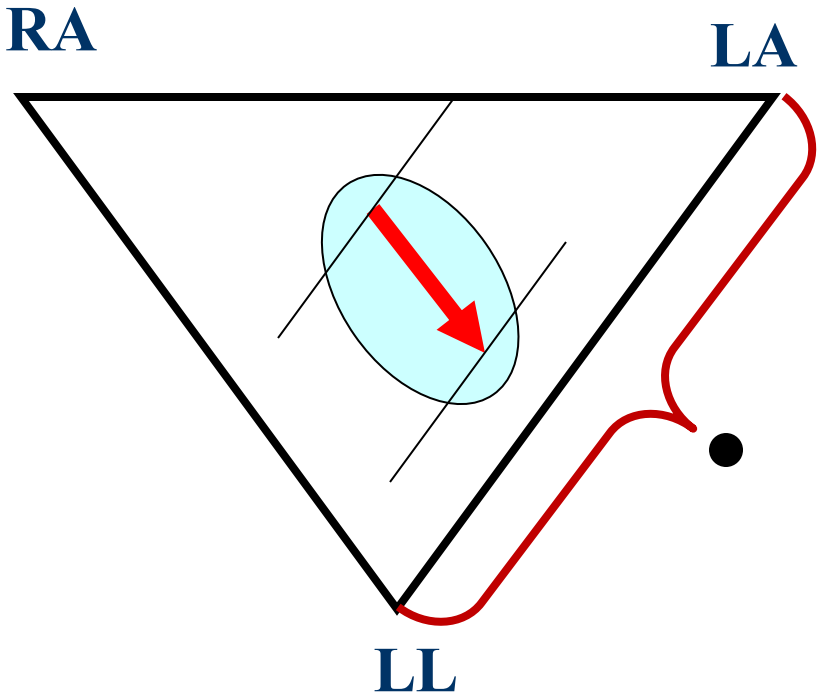
3 Bipolar Limb Leads:

I = RA vs. LA (+)

II = RA vs. LL (+)

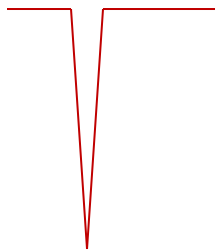


III = LA vs. LL (+)



3 Augmented Limb Leads:

aVR = (LA-LL) vs. RA(+)



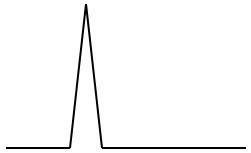
AV = R wave not S

ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

3 Bipolar Limb Leads:

I = RA vs. LA (+)

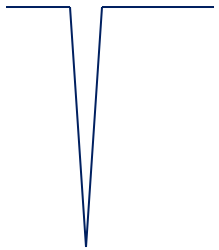
II = RA vs. LL (+)



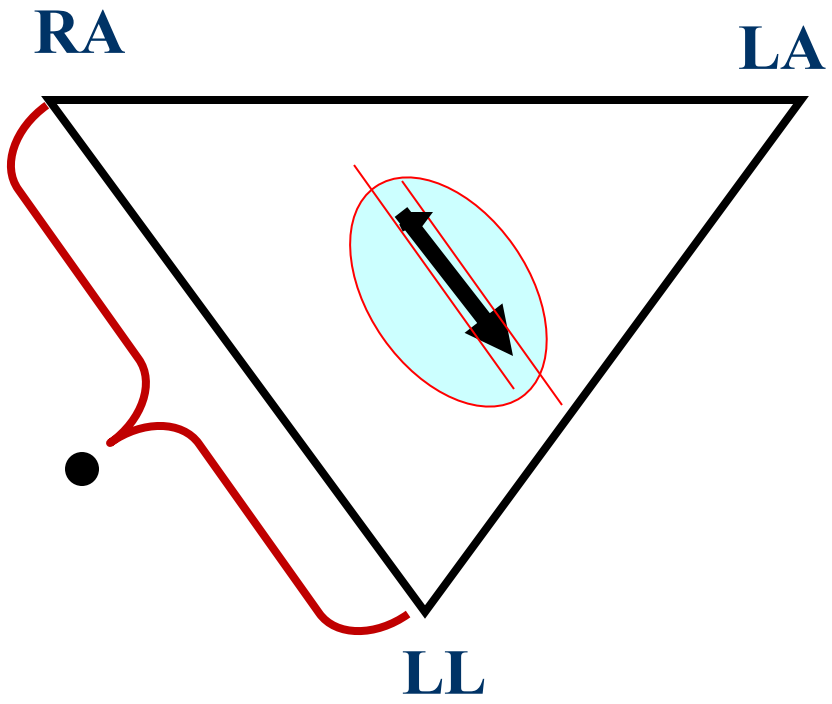
III = LA vs. LL (+)

3 Augmented Limb Leads:

aVR = (LA-LL) vs. RA(+)



aVL = (RA-LL) vs. LA(+)



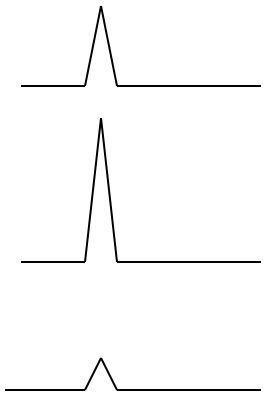
ECG Recordings (QRS Vector pointing leftward, inferiorly & anteriorly)

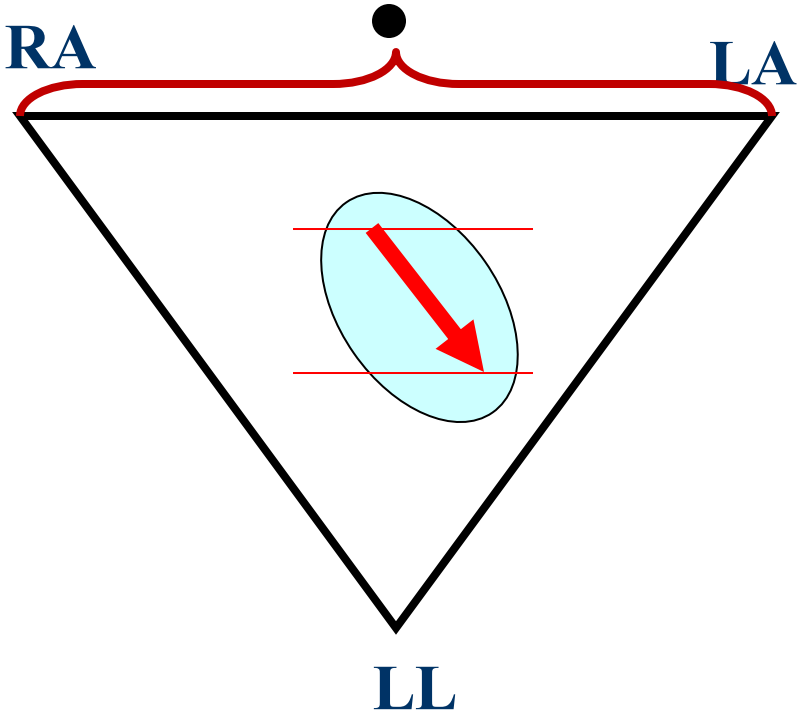
3 Bipolar Limb Leads:

I = RA vs. LA (+)

II = RA vs. LL (+)

III = LA vs. LL (+)



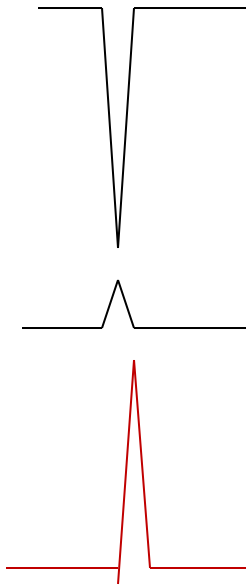


3 Augmented Limb Leads:

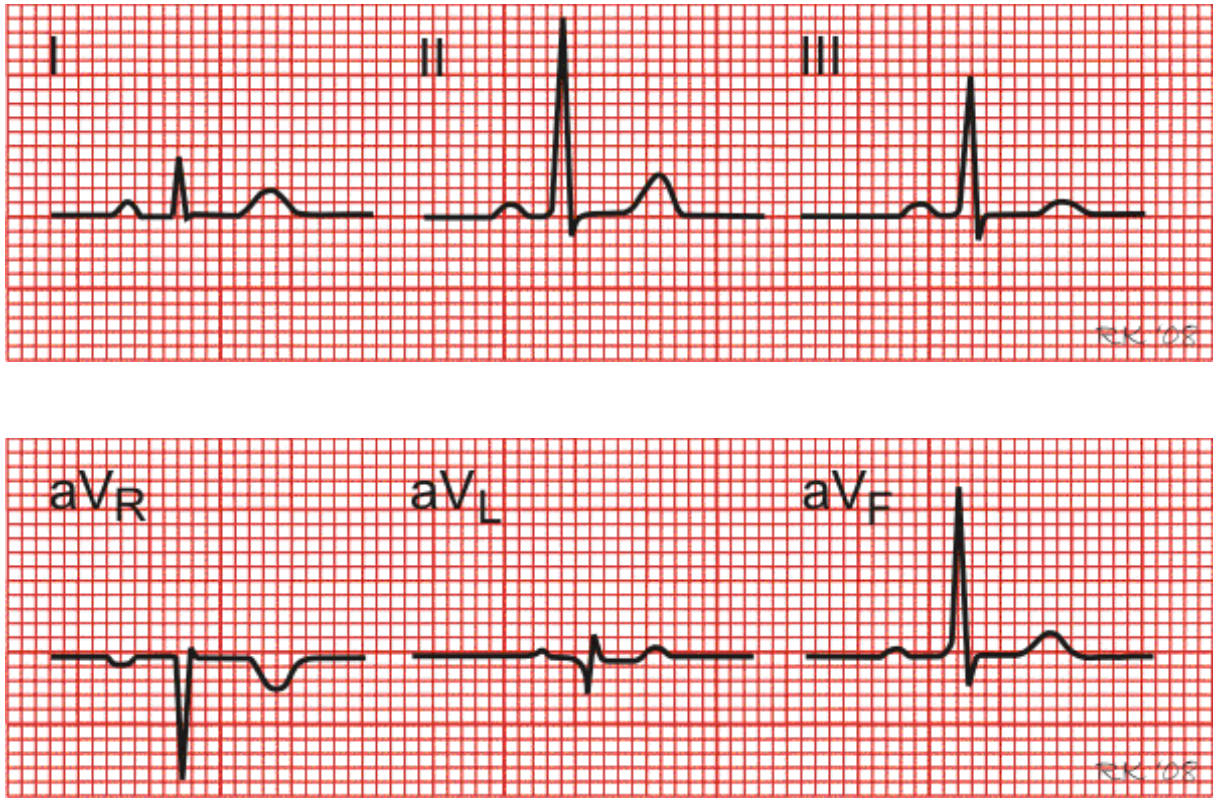
aVR = (LA-LL) vs. RA(+)

aVL = (RA-LL) vs. LA(+)

aVF = (RA-LA) vs. LL(+)



Bipolar and Uniploar Limb Leads

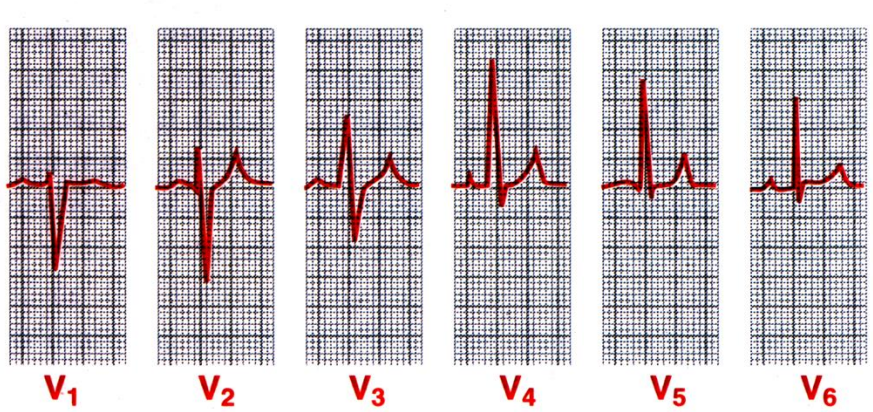


Summary :
The center of the heart = zero potential (neutral).
Wilson made the first unipolar system using high resistances.
Goldsberger modified it and made the **augmented leads** (aVR, aVL, aVF).
Now we have **6 limb leads (3 bipolar + 3 unipolar)** in the **frontal plane**.
Chest (precordial) leads record from the **transverse plane**.
The ECG deflection depends on the **direction of the mean vector** relative to the **positive electrode**.

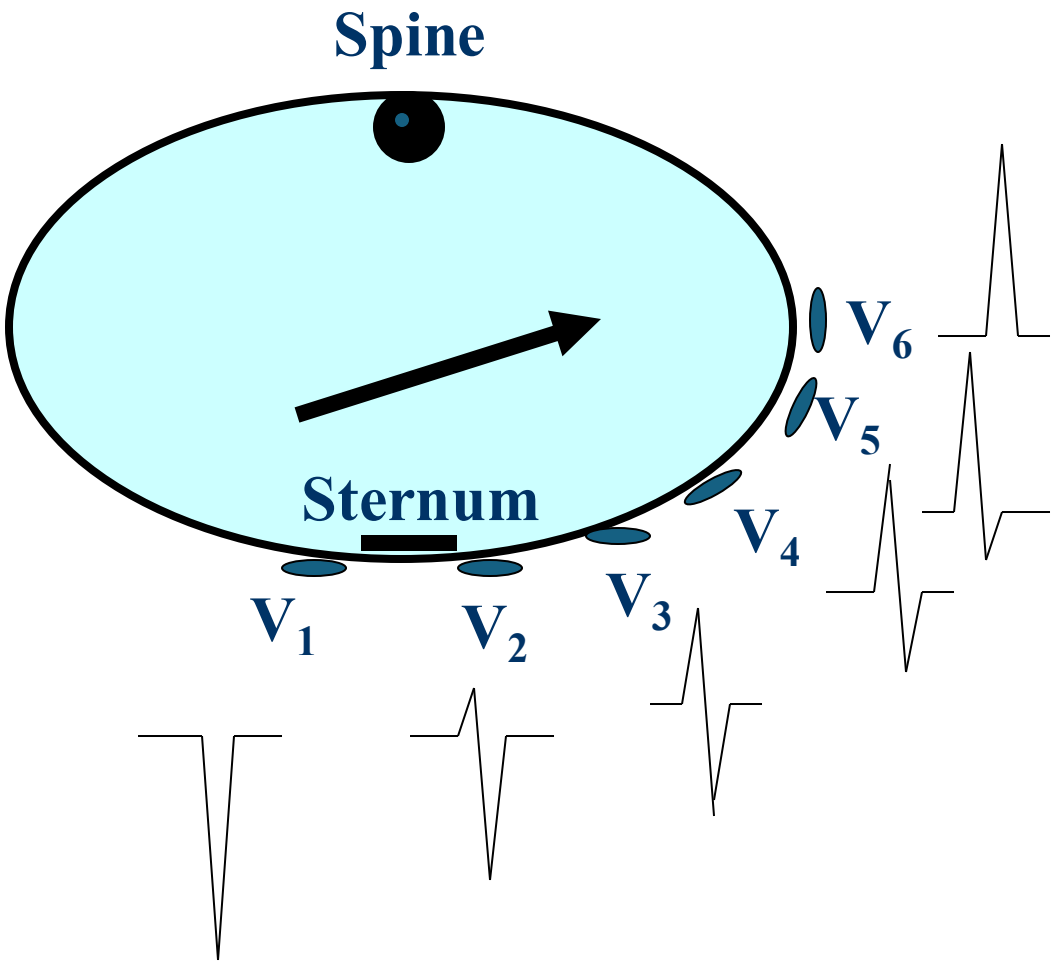
لا إله إلا أنت سبحانك إنّا كنا من الظالمين

Other EKG Leads

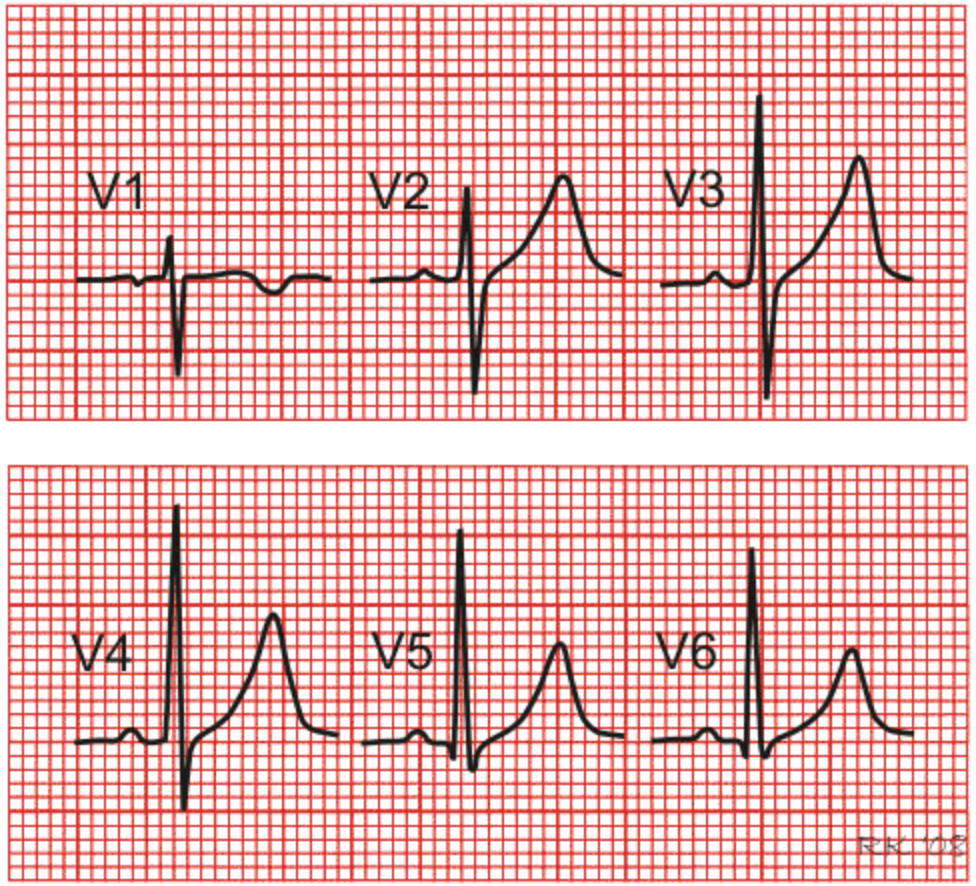
- A later advancement in electrocardiography introduced the use of **chest (precordial) leads** to analyze the heart's electrical activity in the **transverse (horizontal) plane**.
- Since the heart's main electrical axis points **leftward and anteriorly**, it became important to record its activity from this viewpoint. To accomplish this, **six precordial leads** were placed on the **anterior chest wall**, each detecting electrical activity from a different horizontal direction.
- These leads are labeled **V_1–V_6**, and they are sometimes also referred to as **C_1–C_6** (where "C" stands for *chest*).
- Chest Leads (Precordial Leads) known as V_1-V_6 are very sensitive to electrical potential changes underneath the electrode.



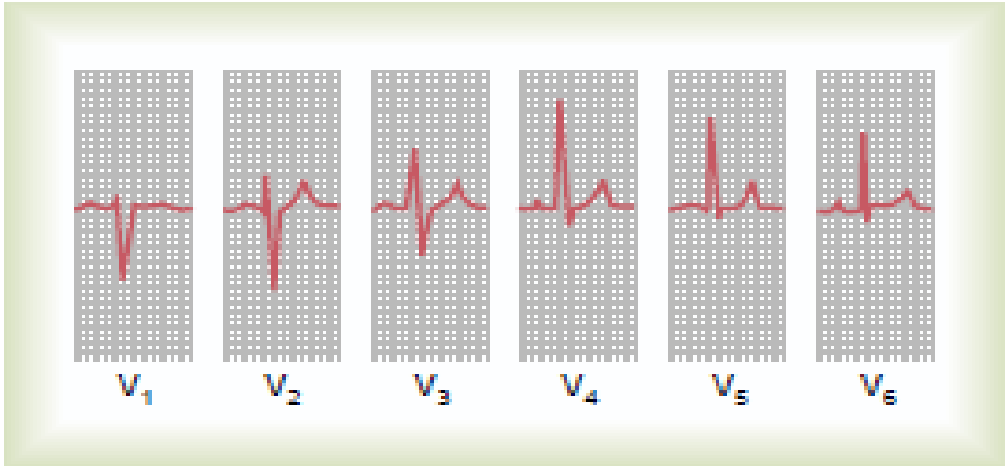
6 PRECORDIAL (CHEST) LEADS



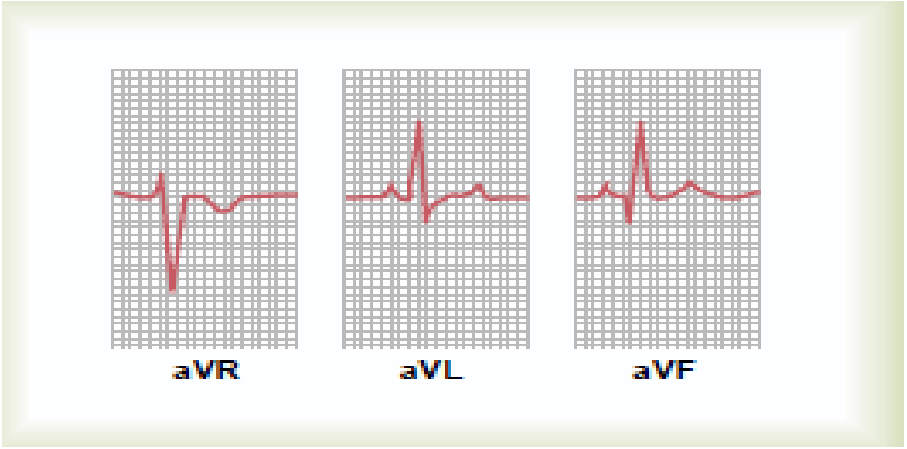
Chest leads (Unipolar)



Uniplolar Leads



6 Chest leads (unipolar)



3 Uipolar leads

This is Complete ECG. In our devices, the ECG traces are usually arranged sequentially rather than stacked.

ECG Recordings: (QRS vector---leftward, inferiorly and anteriorly

3 Bipolar Limb Leads

I = RA vs. LA(+)

II = RA vs. LL(+)

III = LA vs. LL(+)

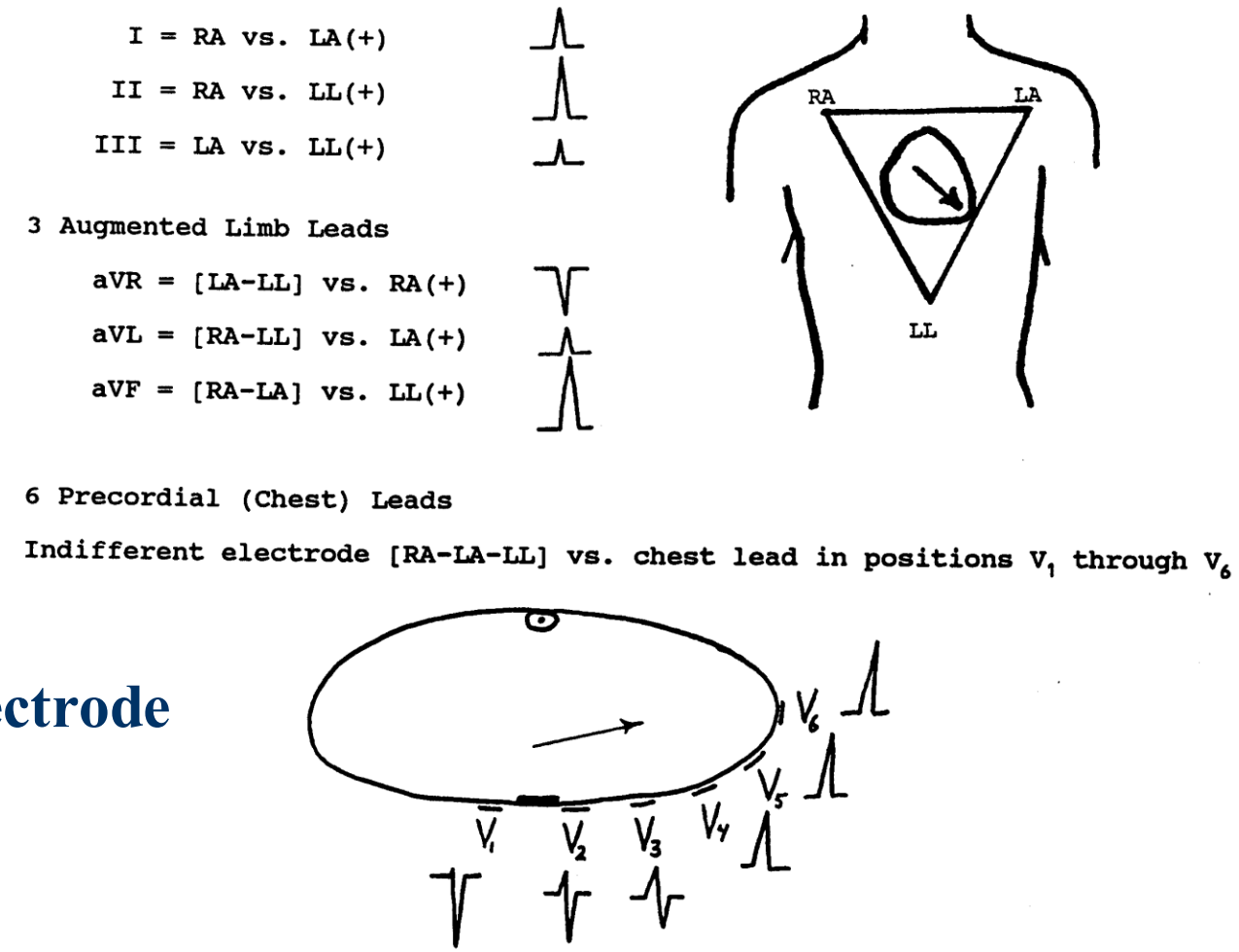
3 Augmented Limb Leads

aVR = (LA-LL) vs. RA(+)

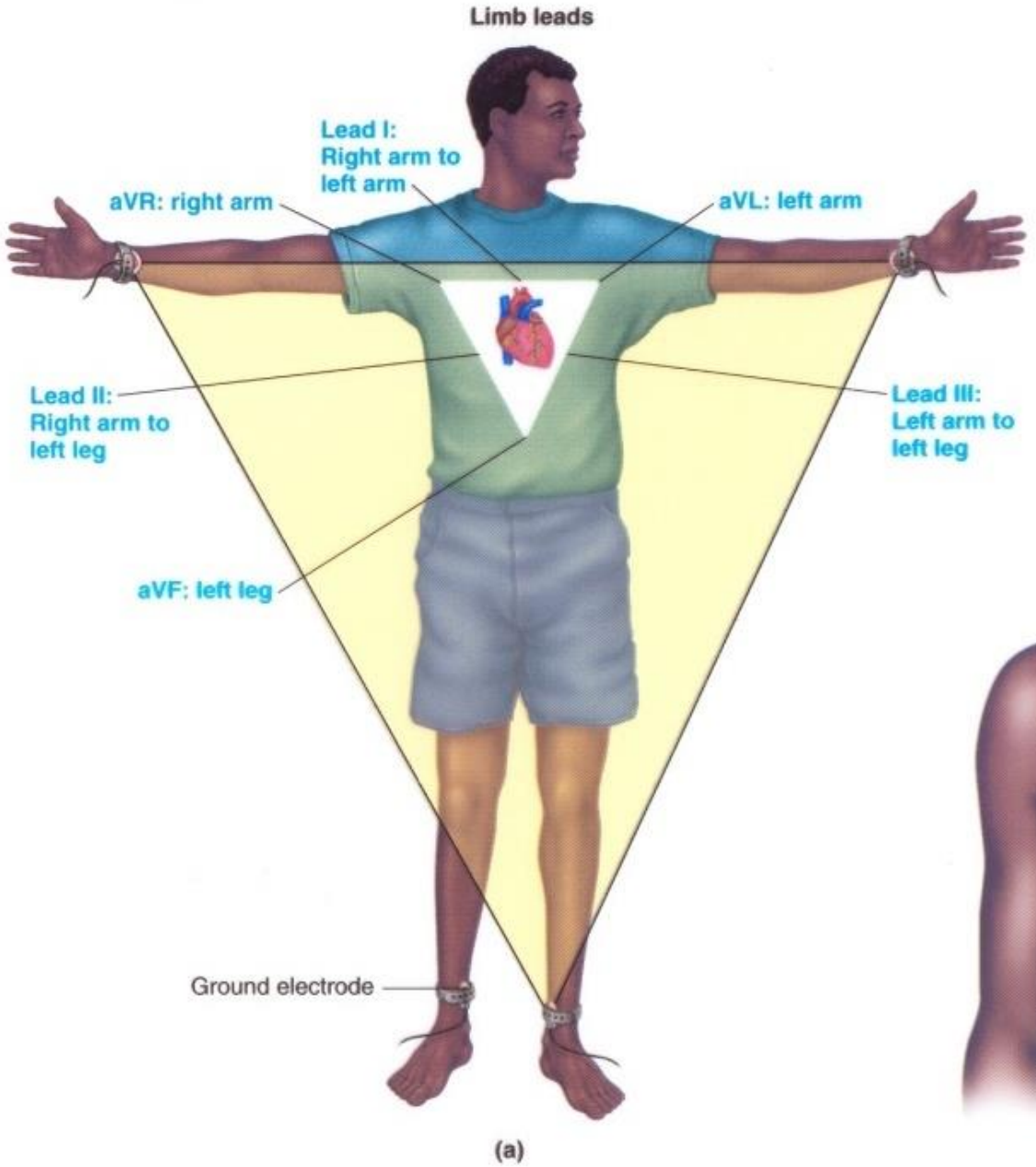
aVL = (RA-LL) vs. LA(+)

aVF = (RA-LA) vs. LL(+)

6 Precordial (Chest) Leads: Indifferent electrode (RA-LA-LL) vs. chest lead moved from position V_1 through position V_6.

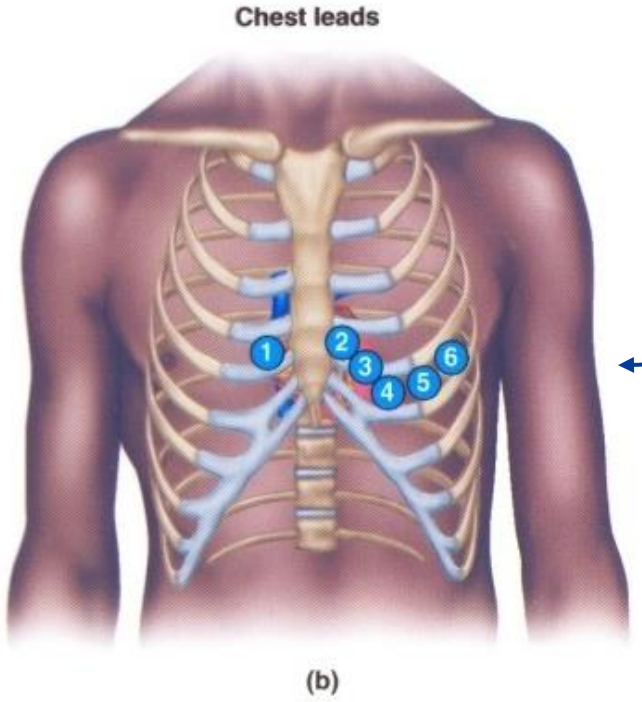


Electrocardiogram leads



- V_1: 4th intercostal space, right sternal border.
- V_2: 4th intercostal space, left sternal border.
- V_4: 5th intercostal space, midclavicular line.
- V_3: Midway between V_2 and V_4.
- V_5: 5th intercostal space, anterior axillary line.
- V_6: 5th intercostal space, mid-axillary line.

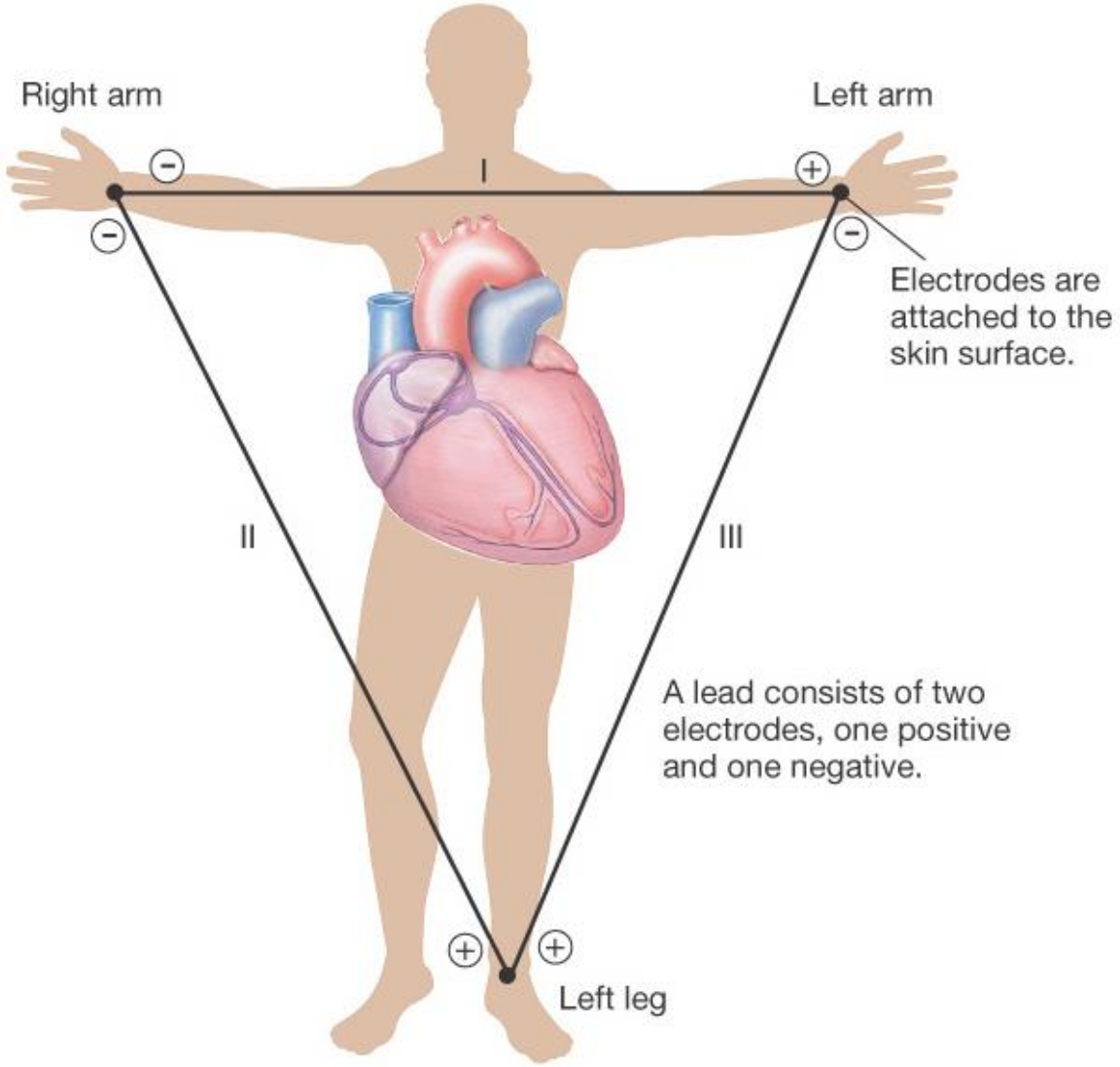
The professor didn't mention them in the lecture, but know them just in case



Chest leads positions

Electrocardiogram (ECG):Electrical Activity of the Heart

- Einthoven's triangle
- P-Wave – atria
- QRS- wave – ventricles
- T-wave – repolarization



Electrocardiography – Normal 2

Faisal I. Mohammed, MD, PhD

لا المال يبقى ولا الأرواح خالدةٌ
لاشيء يبقى سوى ذكراك والأثر

يفنى العباد ولا تفنى صنائعهم
فاختر لنفسك ما يحلو به الأثر

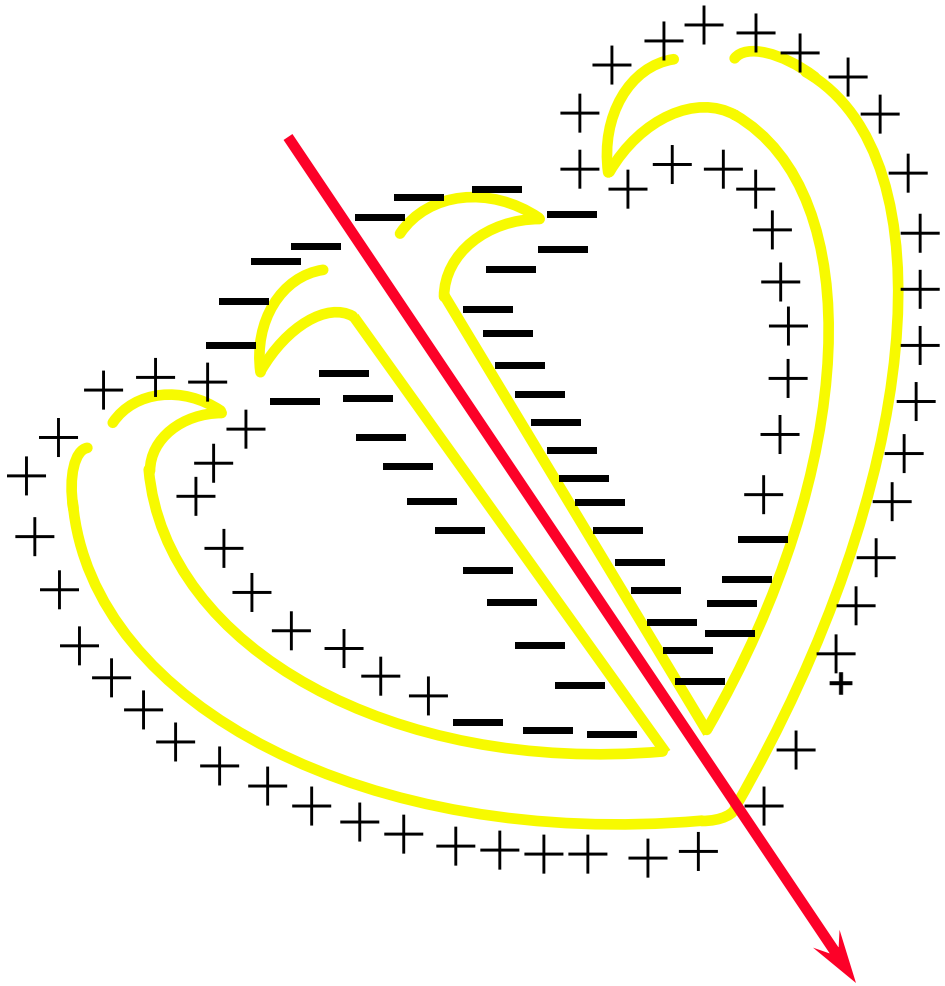
Objectives

- Recognize the normal ECG tracing
- Calculate the heart rate
- Determine the rhythm
- Calculate the length of intervals and determine the segments deflections
- Draw the Hexagonal axis of the ECG
- Find the mean electrical axis of QRS (Ventricular depolarization)

Principles of Vectorial Analysis of EKG's

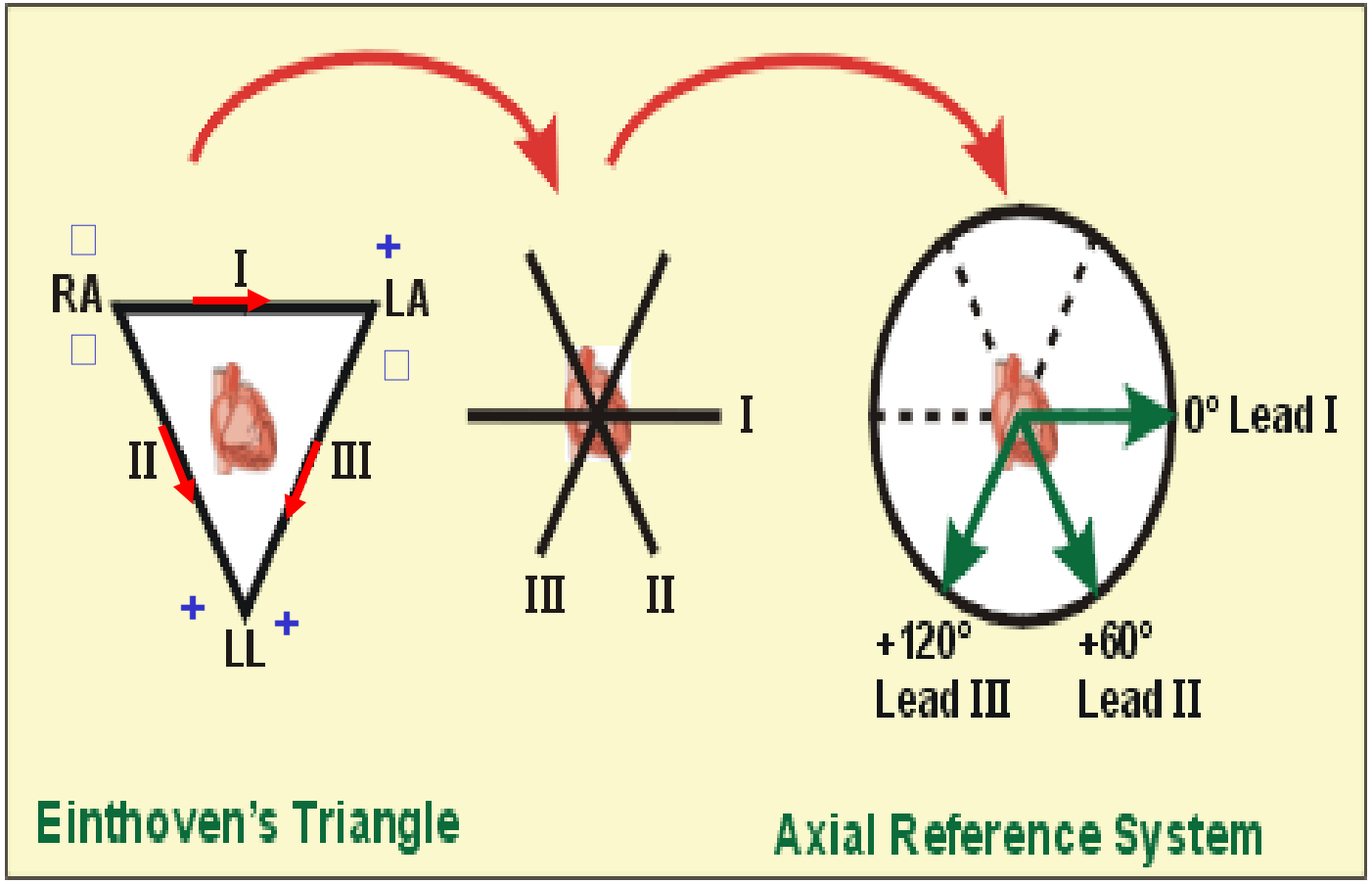
- The current in the heart flows from the area of depolarization to the polarized areas, and the electrical potential generated can be represented by a vector, with the *arrowhead pointing in the positive direction*.
- The length of the vector is *proportional to the voltage of the potential*.
- The generated potential at any instance can be represented by an *instantaneous mean vector.*
- The normal mean QRS vector is 60^{o} (-30° - 110°)

Mean Vector Through the Partially Depolarized Heart



Mean vector is to **left and anterior.**

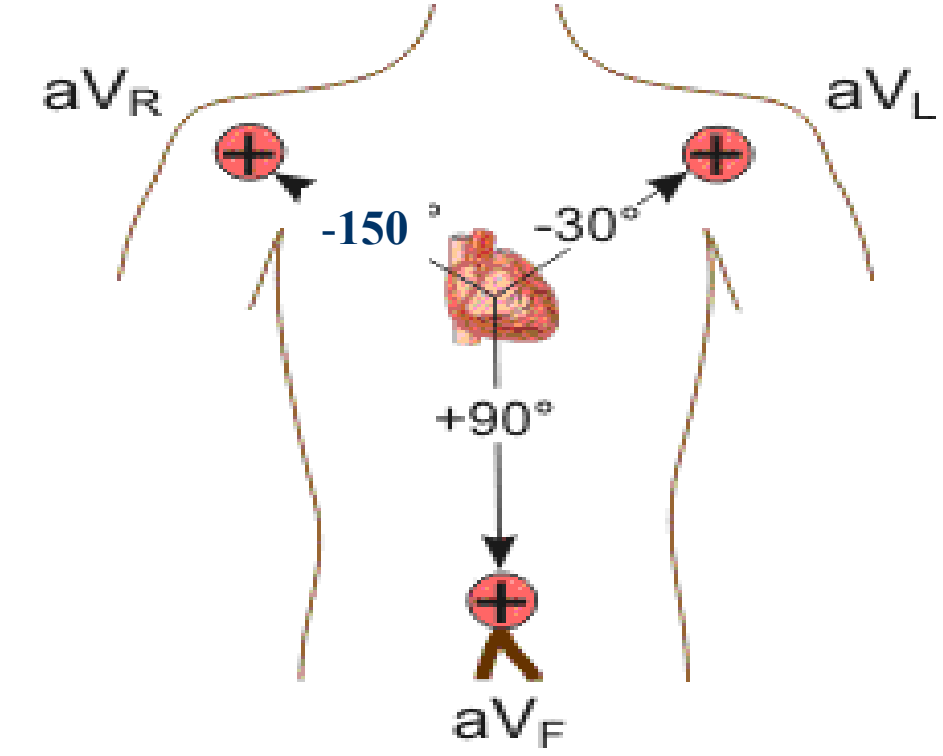
Einthoven’s triangle and law

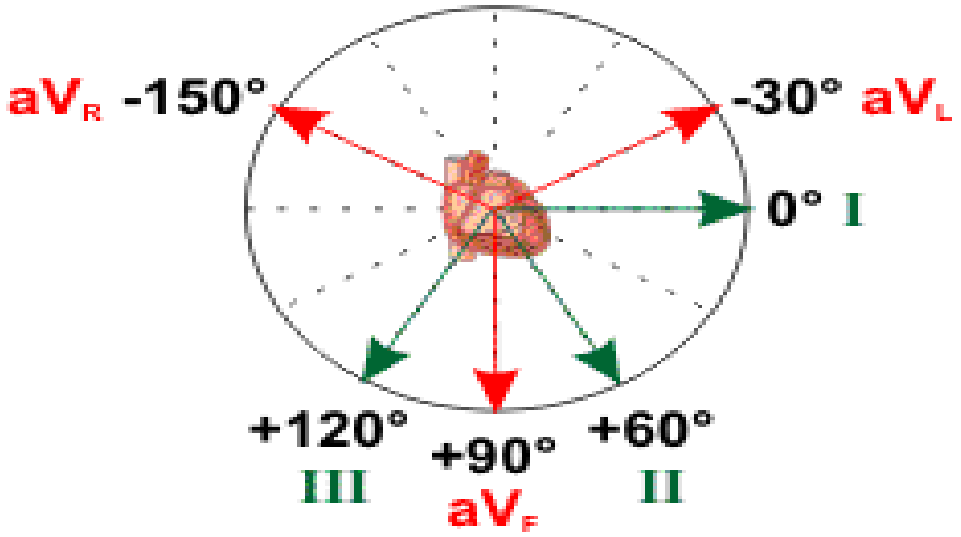


we calculate or analyze the **mean QRS vector** (electrical axis) through this method:

1. **Goal:** We want all **three limb leads** (Lead I, II, III) to **intersect at one point**, which is the **center of the heart**.
2. **Transforming the leads:**
1. Move the **axis of Lead I** so it passes through the **heart center**, keeping its value the same (parallel translation).
2. Place Leads II and III so that each forms a **60° angle** with the others, creating the **Einthoven triangle**.
3. **Leads as vectors:**
1. Each lead can be represented as a **vector** (with a magnitude and direction).
2. When **analyzing** angles between vectors:
1. **Clockwise rotation = positive angle**
2. **Counterclockwise rotation = negative angle**
4. **Why we draw Leads I, II, III:**
1. To get **better information about what is happening in the heart**.
2. By using the triangle, we can **project the mean QRS vector onto each lead** and calculate its magnitude and direction accurately.

Key idea: Any **equilateral triangle** works for this method — dropping perpendiculars from the mean vector onto the sides gives the **vector components**, which lets us reconstruct the **electrical axis.**



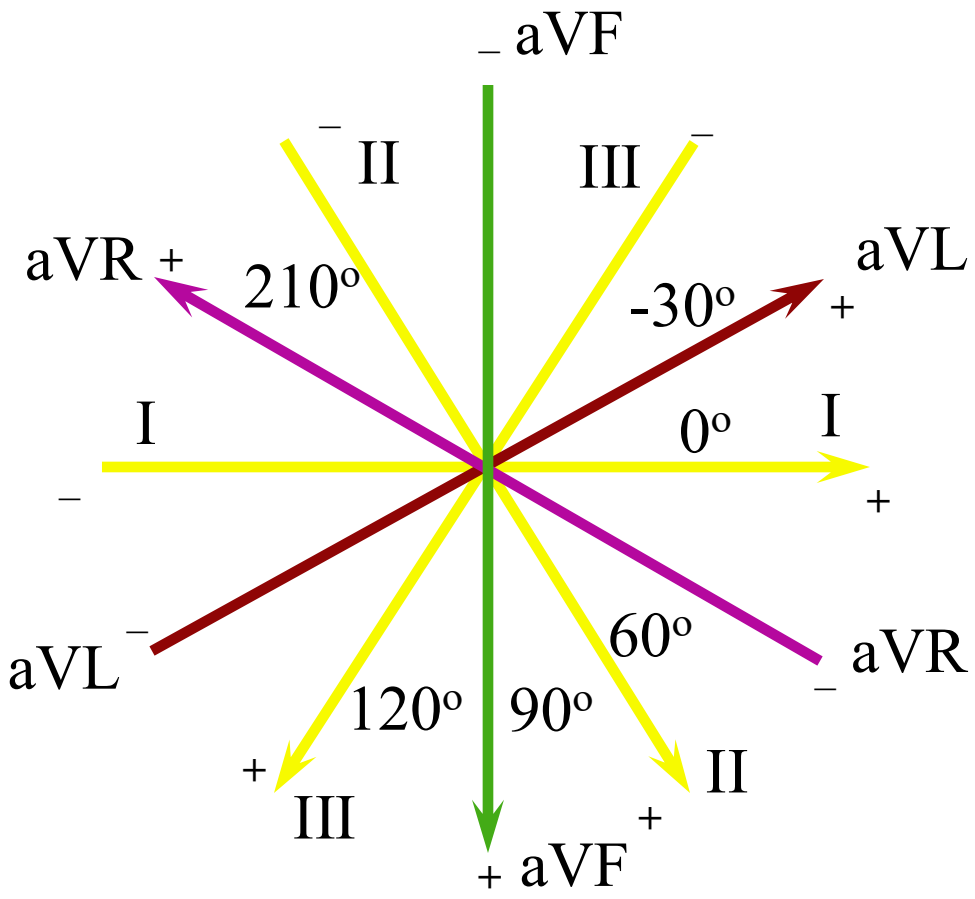


Explaination in the upcoming slides.

Principles of Vectorial Analysis of EKG's (cont'd)

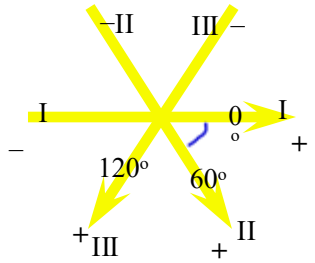
Go to next slide.

Axes of the Three Bipolar and Augmented Leads

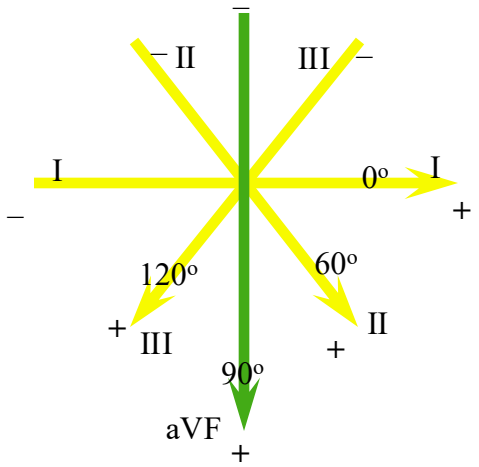


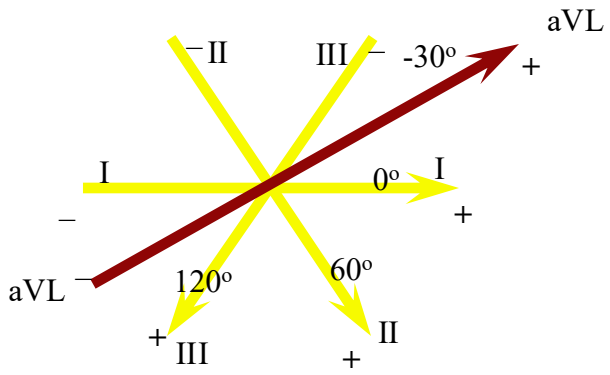
عن النبي أنه قال :
" مَنْ قرأَ آيةَ الكُرسِيِّ دُبُرَ كلِّ صلاةٍ مكتوبةٍ،
لمْ يمنعْهُ من دُخُولِ الجنةَ إلَّا أنْ يمُوت "

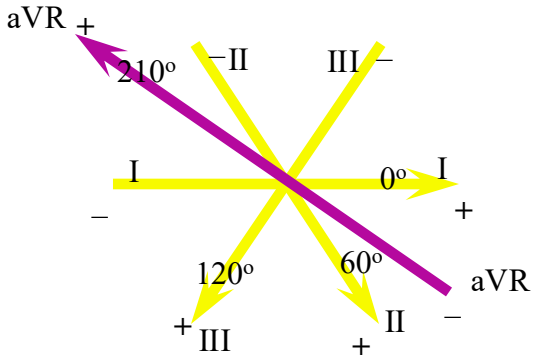
- ✓ There's a 60 degree between lead I, II and III.



- ✓ Each of aVL/aVF/aVR divides the 60 angle into two equal 30 degree.



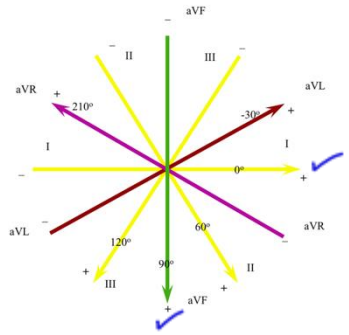




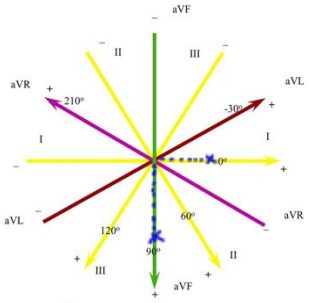
- ✓ There's always two leads perpendicular to each other since they all have either 30,60,90 degree.
- ✓ We can use these rules to calculate the mean electrical access by taking any two limb leads. Steps in next slide

Steps:

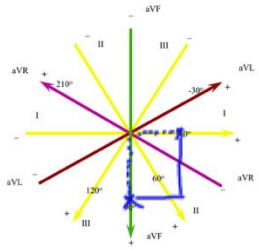
1. Choose two leads



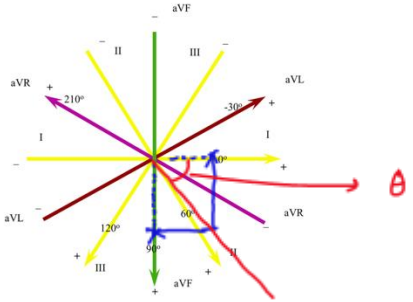
2. Indicate a perpendicular line on the point that represents the value along the vector



3. Cross link the two lines

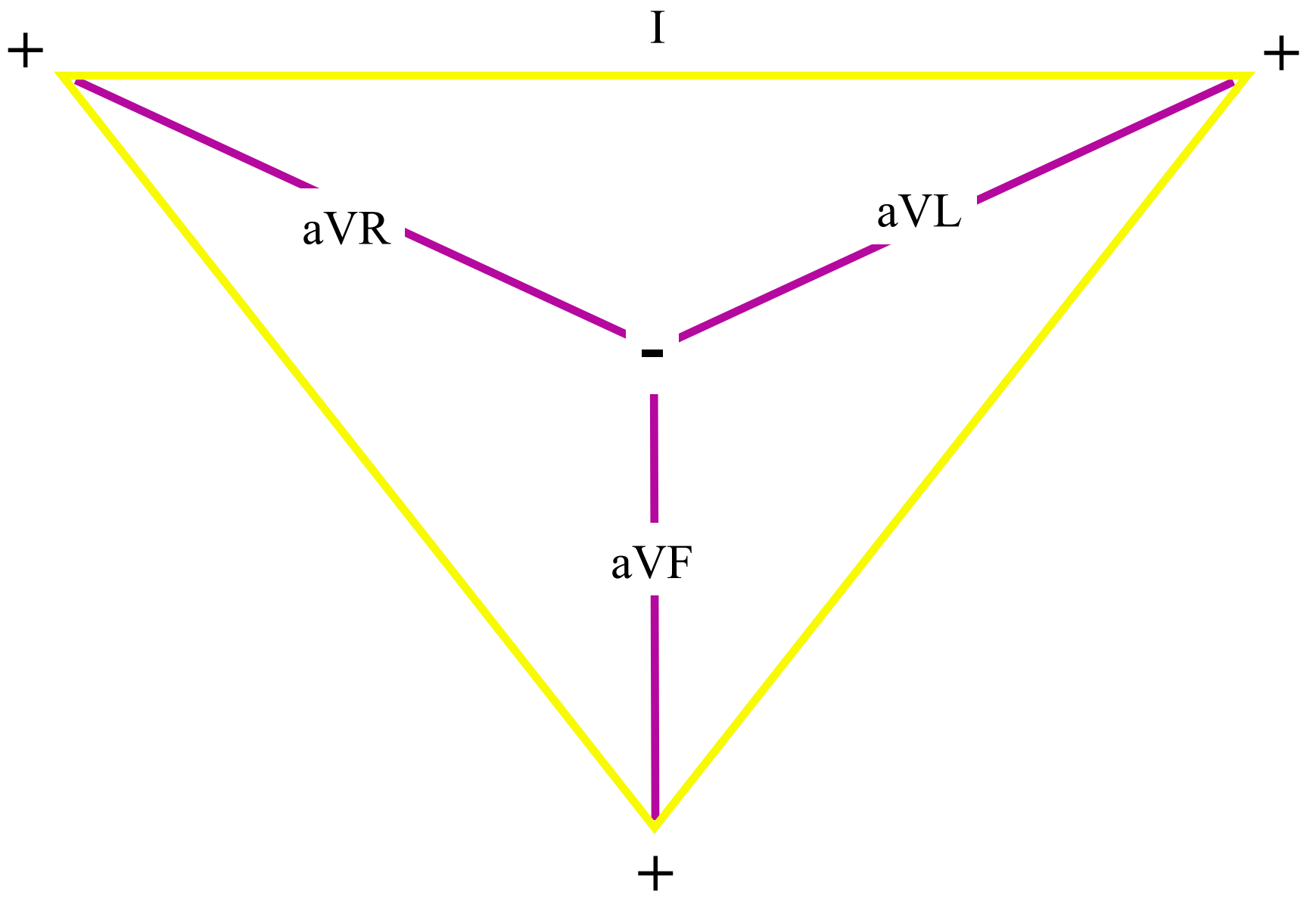


4. Caculate the angle



Clinically, normal value range is between (0–+90)
But it's wider in physiology (-30–+110)

Axes of the Unipolar Limb Leads



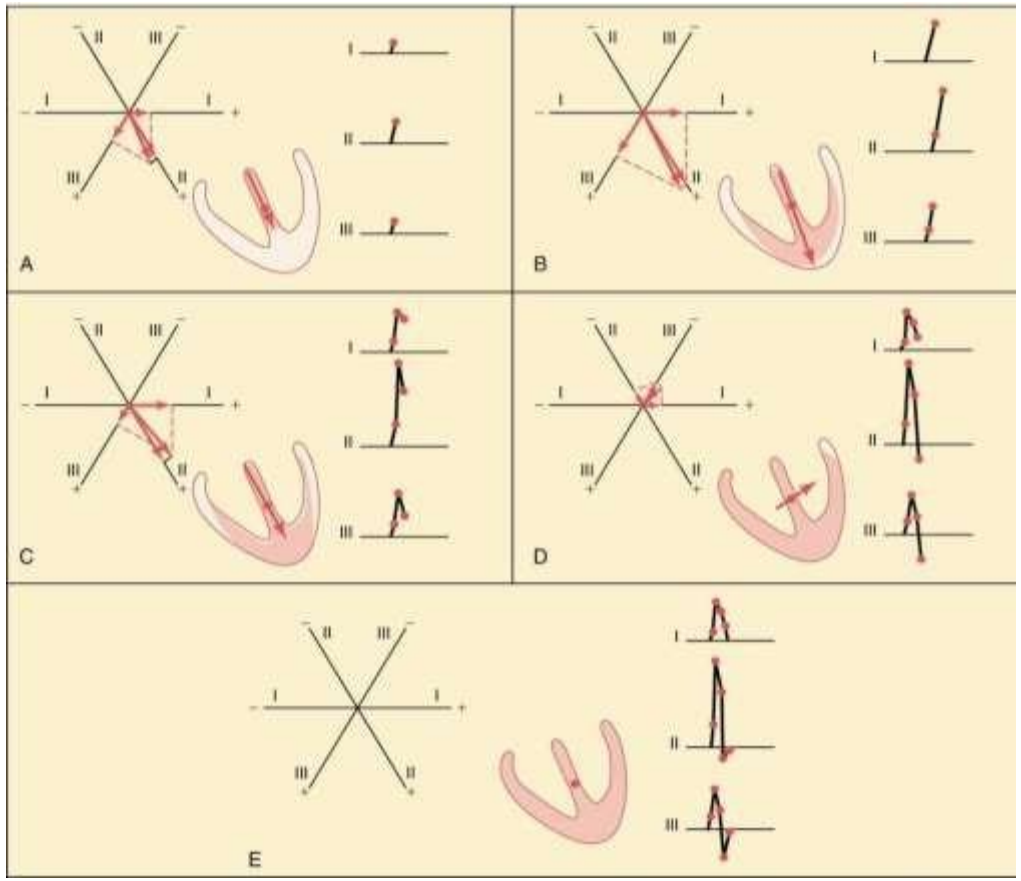
Principles of Vectorial Analysis of EKG's (cont'd)

- *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.*

Principles of Vectorial Analysis of EKG's (cont'd)

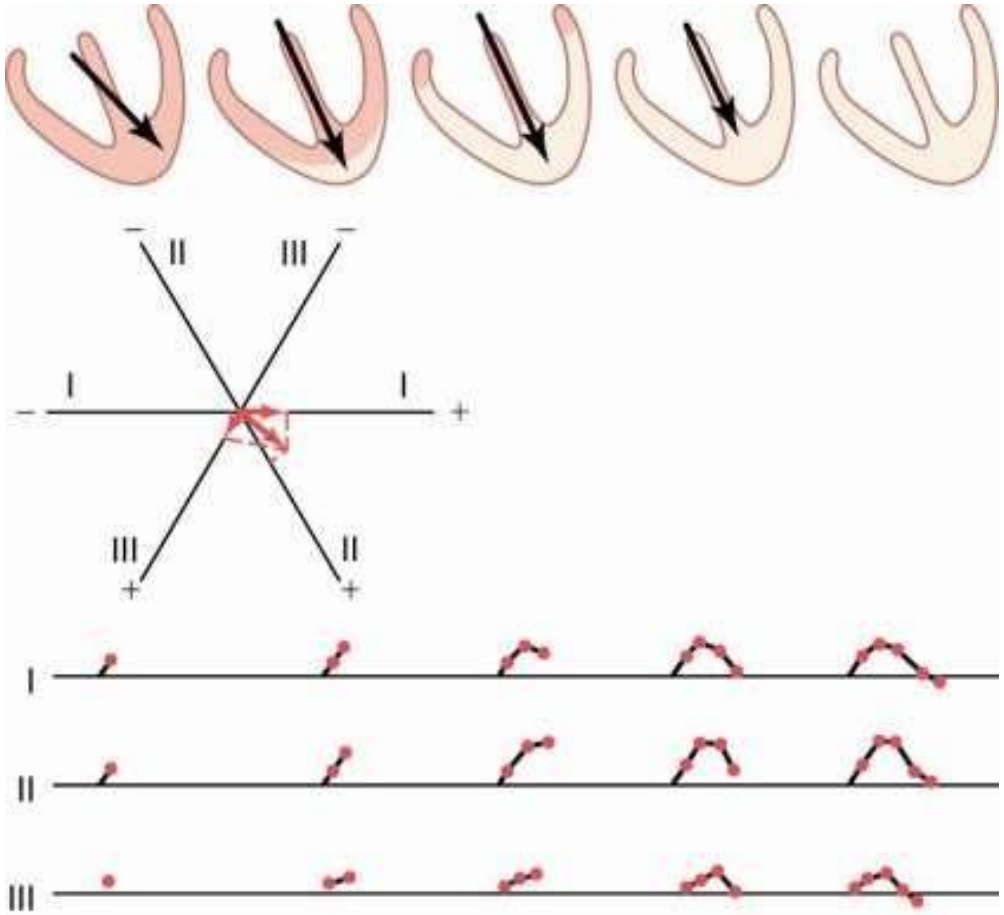


Principles of Vectorial Analysis of EKG's (cont'd)

- 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 60^{o}.
- 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.

The T Wave (Ventricular Repolarization)

- First area to repolarize is near the apex of the heart.
- Last areas, in general, to depolarize are the first to repolarize.
- Repolarized areas will have a + charge first; therefore, a + net vector occurs and a positive T wave



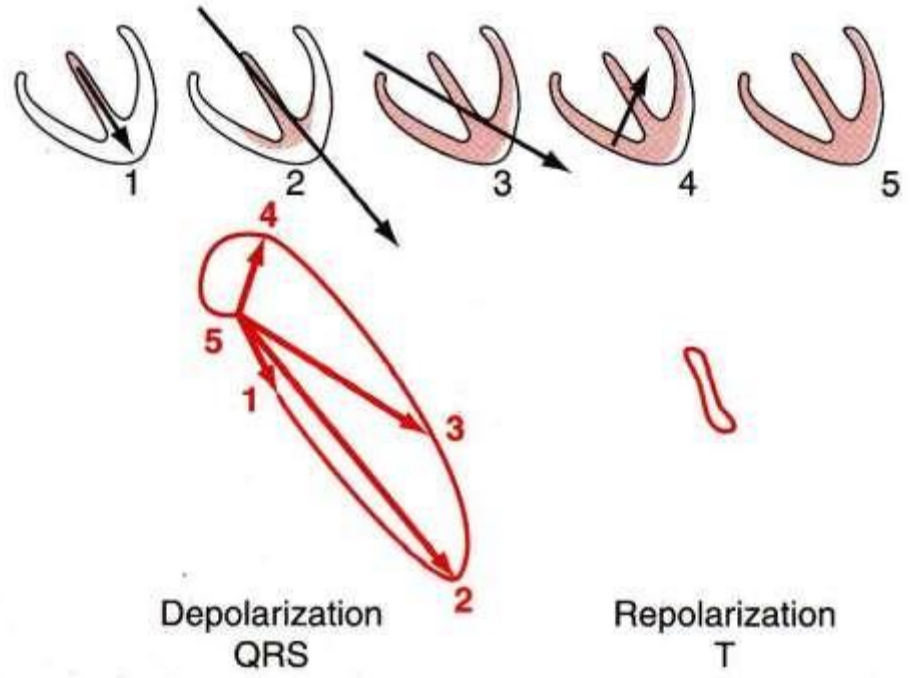
Atrial Depolarization (P-Wave) and Atrial Repolarization (Atrial T Wave)

- Atrial depolarization begins at sinus node and spreads toward A-V node.
- This should give a + vector in leads I, II, and III.
- Atrial repolarization can't be seen because it is masked by QRS complex.
- 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

Vectorcardiogram

- This traces vectors throughout cardiac cycle.

- When half of the ventricle is depolarized, vector is largest.

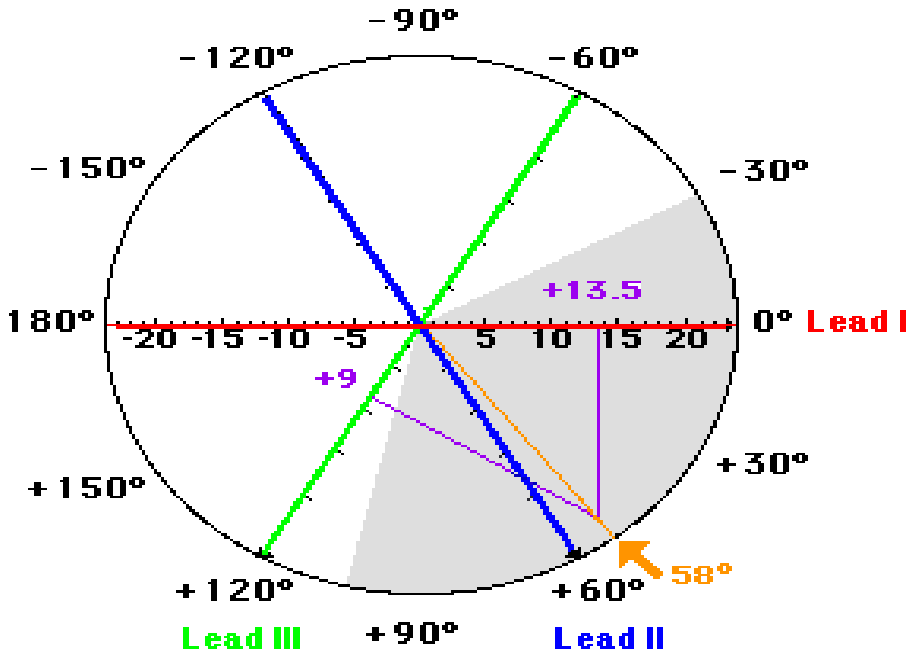


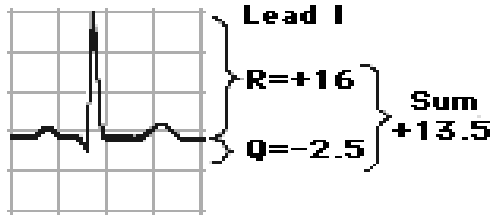
- Note zero reference point, number 5, is point of full depolarization

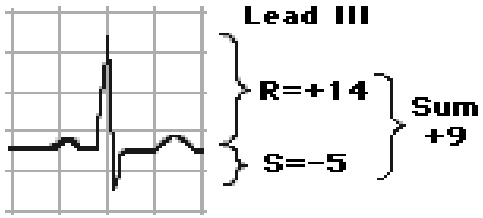
Determining Mean Electrical Axis

- Use 2 different leads
- Measure the sum of the height and the negative depth of the QRS complex
- Measure that value in mm onto the axis of the lead and draw perpendicular lines
- The intersection is at the angle of the mean axis.

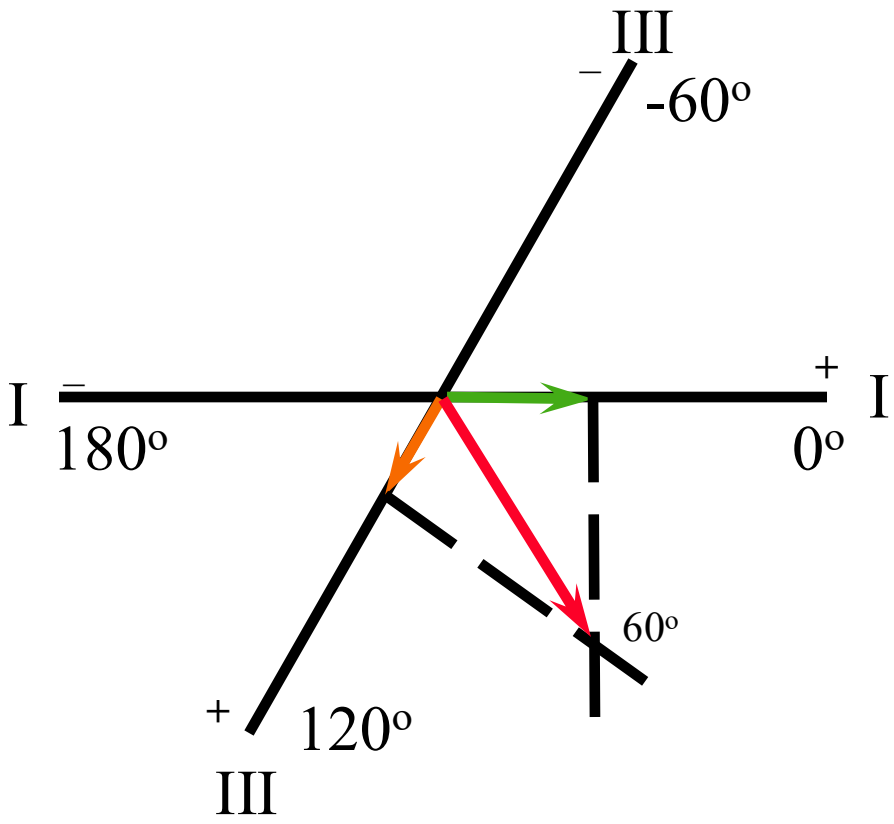
Same concept
Here, lead I and III were chosen, then SAME STEPS mentioned above.



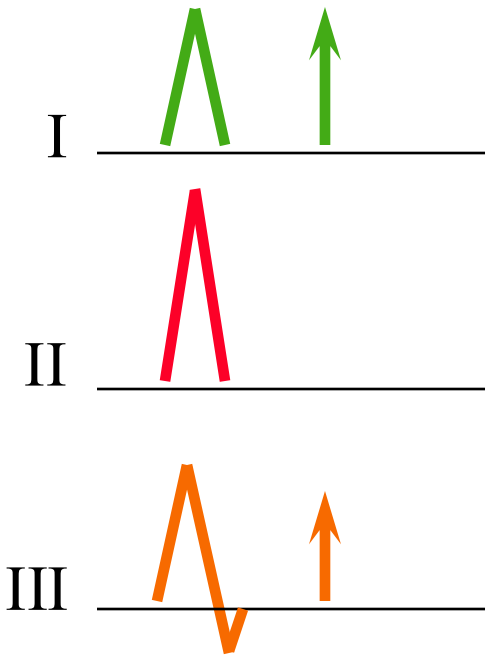


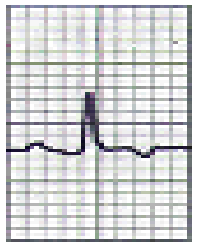


Plot of the Mean Electrical Axis of the Heart from Two Electrocardiographic Leads



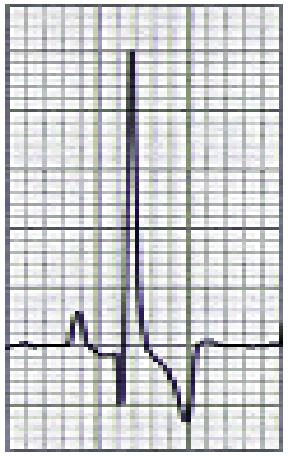
Same thing here.





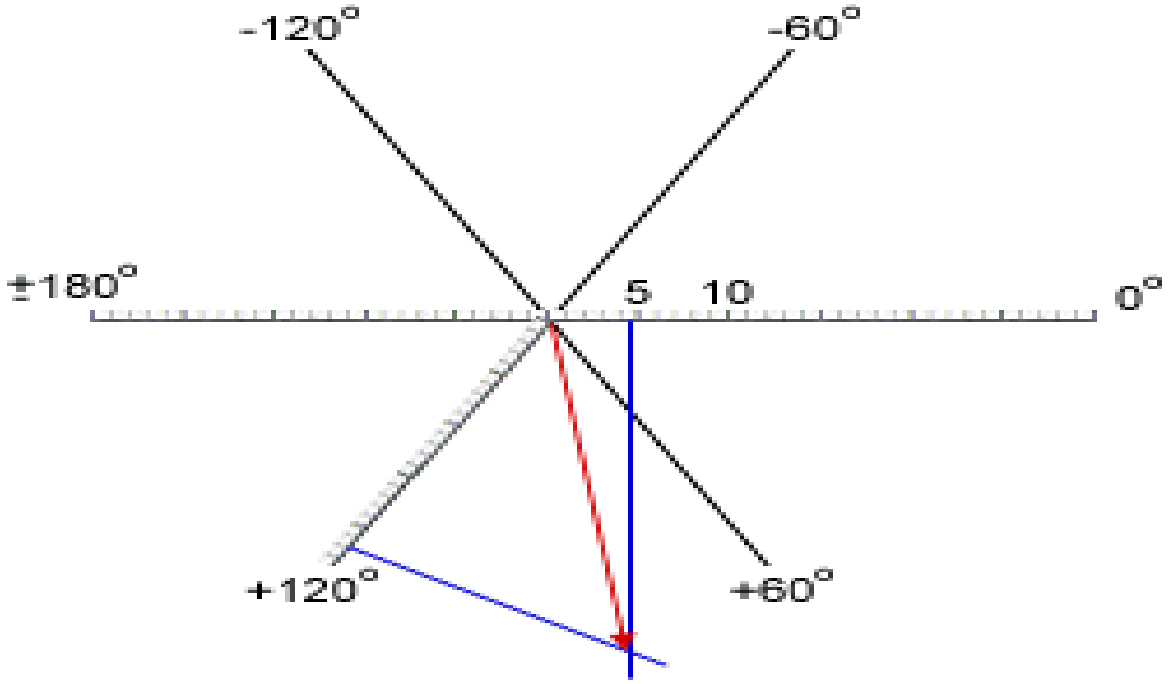
Lead I

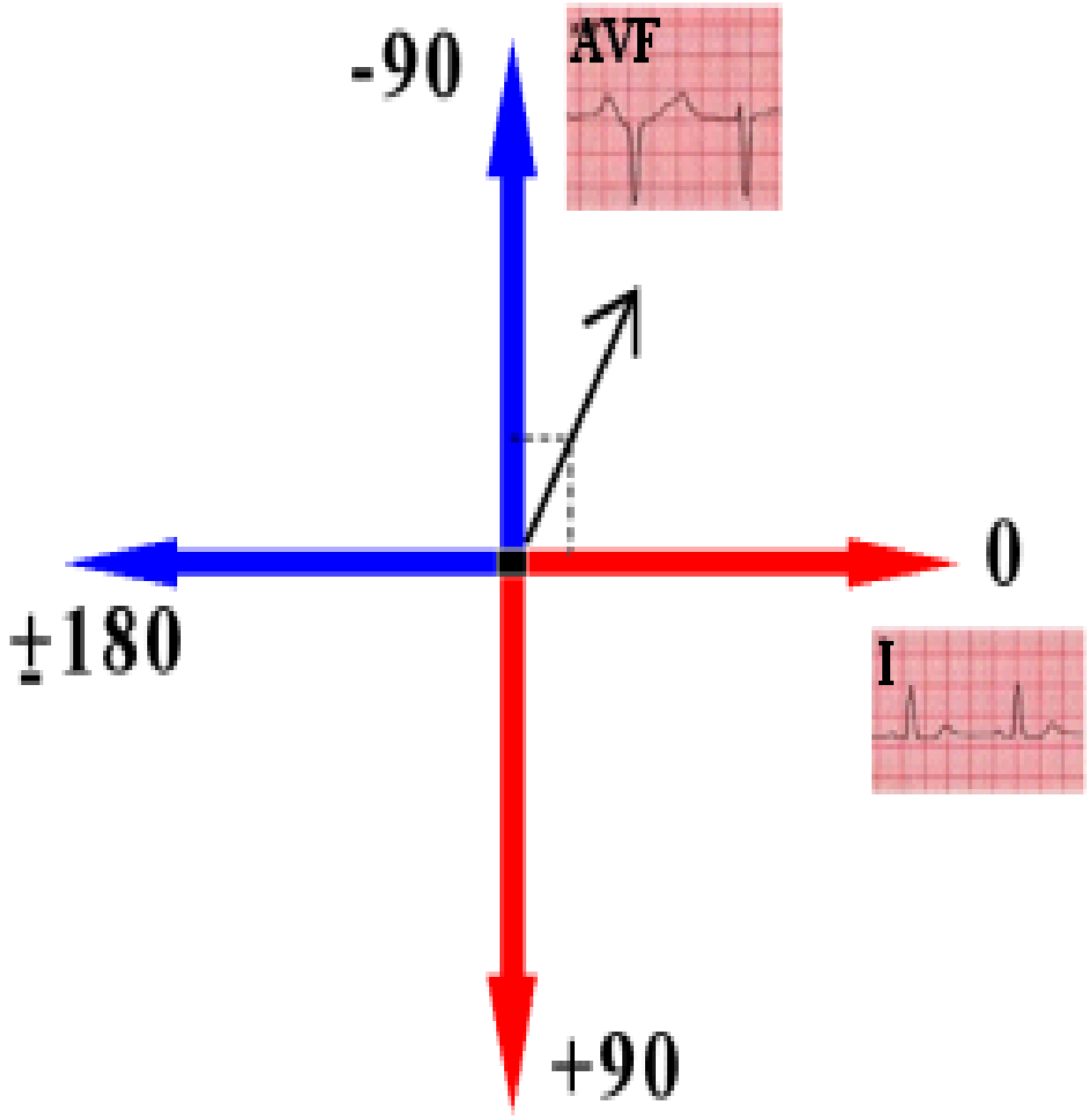
Q = - 0.5
R = +5
+4.5



Lead III

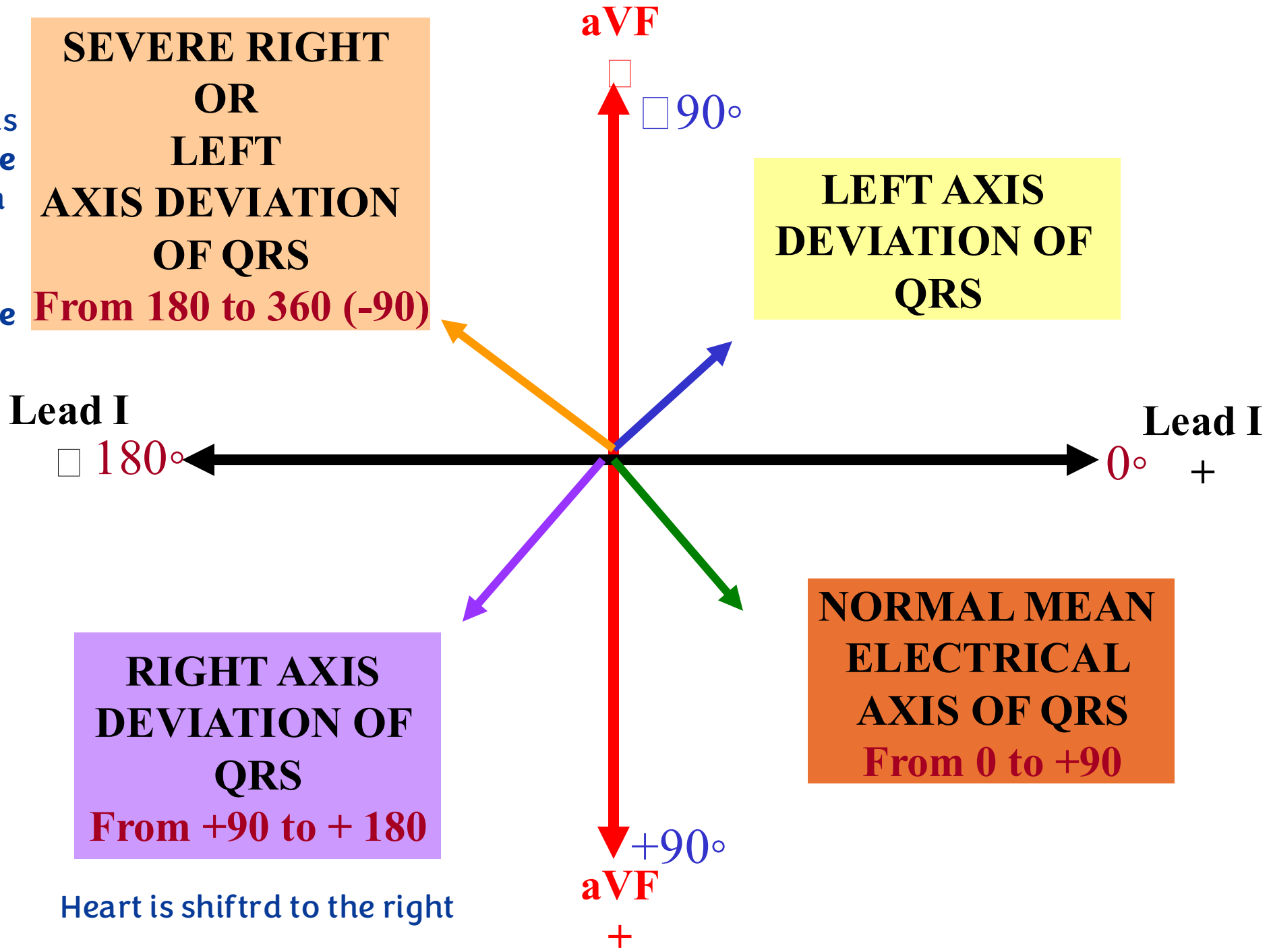
Q = - 4
R = +26
+22




-90
aVF
0
±180
I
+90

In **right heart disease**, the mean QRS axis deviates **to the right**, while in **left heart disease**, it deviates **to the left.**

SEVERE RIGHT OR LEFT AXIS DEVIATION OF QRS
From 180 to 360 (-90)



LEFT AXIS DEVIATION OF QRS

RIGHT AXIS DEVIATION OF QRS
From +90 to + 180

NORMAL MEAN ELECTRICAL AXIS OF QRS
From 0 to +90

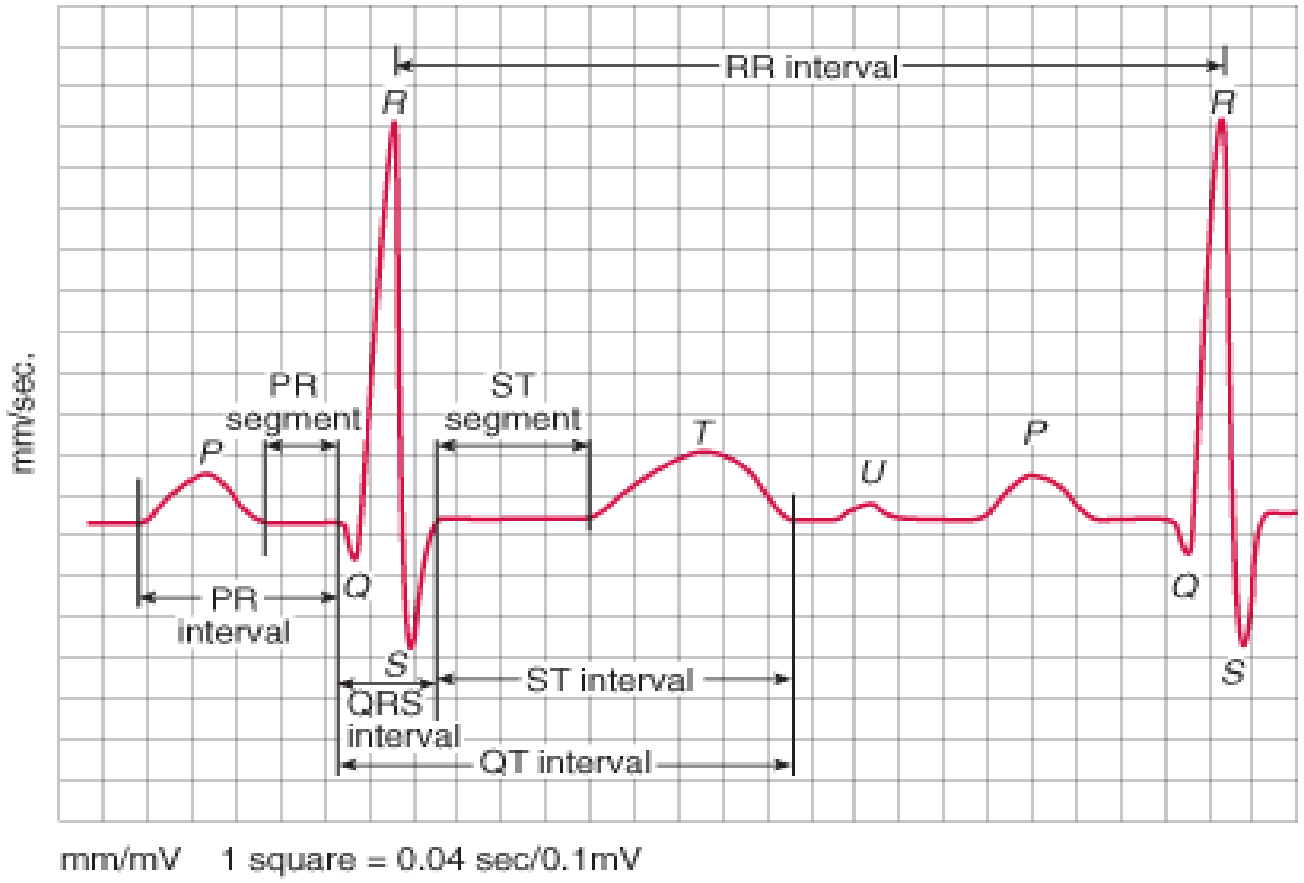
Heart is shiftrd to the right

Heart Rate Calculation

- R-R interval = 0.83 sec
- Heart rate = (60 sec)/(0.83 sec) = 72 beats/min

  min beat

ECG Calculations



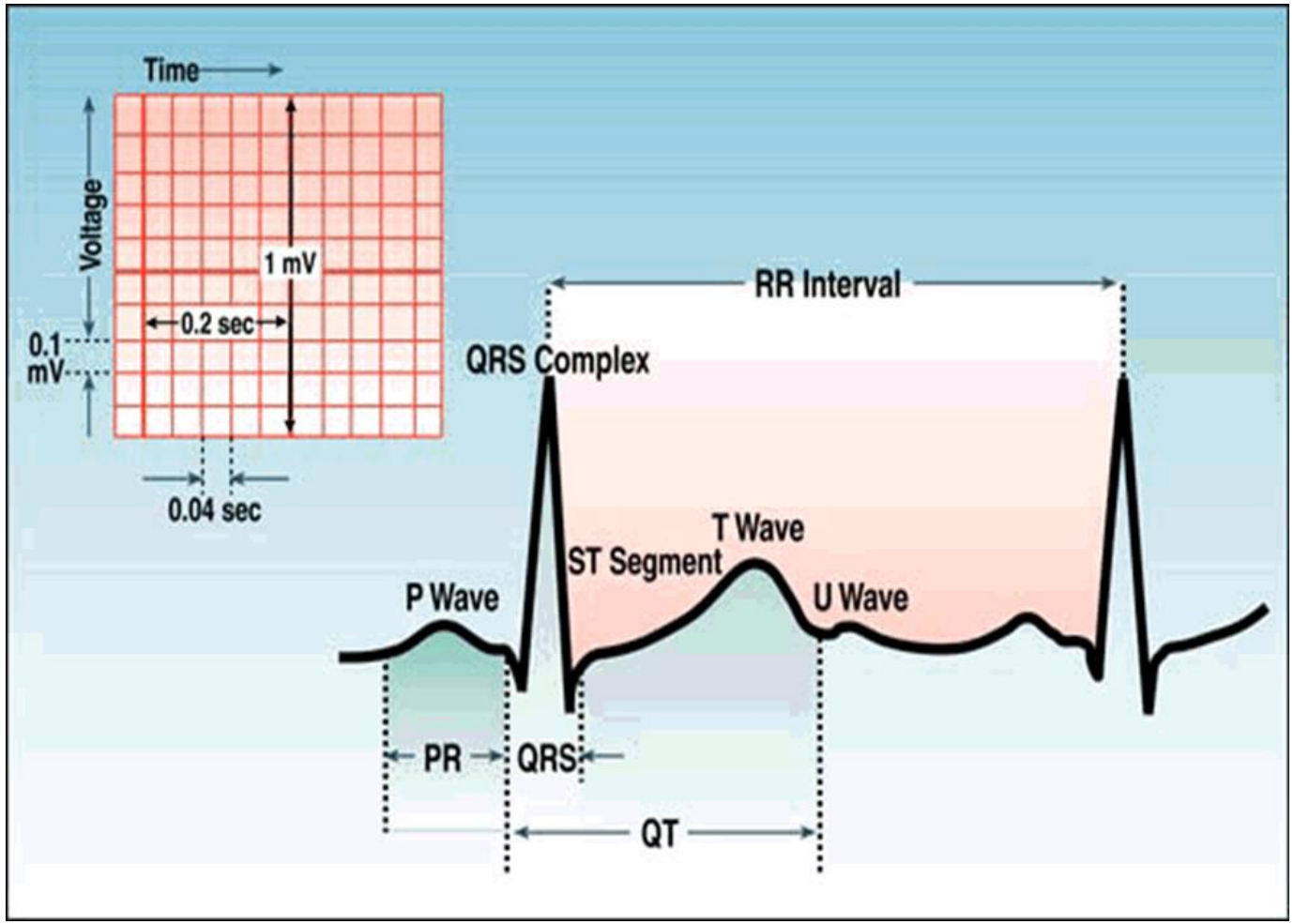
أعوذ بك من شرِّ نفسي"
وشرِّ الشيطان
وشِرْكِهِ
وأن أقترف على نفسي سوءًا
"أو أجرّه إلى مسلم

أعوذ بك يا رب من أن أقترف السوء بنفسي
أو أجرَّه إلى نفسي
أو أجرّه إلى أخي المسلم
.أو أتسبب في إيصاله إليه وإيقاعه فيه

يستعيذ المسلم كل صباح ومساء من أن
. يمسّه الشر، ومن أن يكون بوابة إيصال الشر

.يرجو أن يحفظه من أذى نفسه لنفسه، ومن أذى نفسه لغيره

ECG Calculations

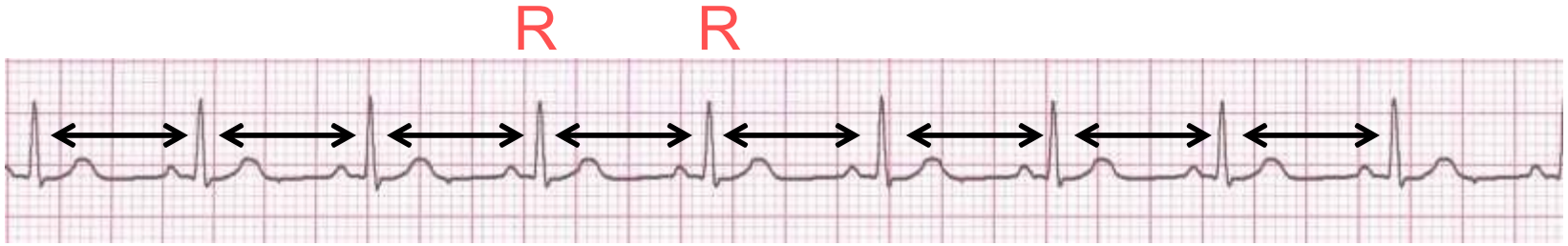


PR and ST segments are important in the cases of MI and angina, bcz they appear downwards or upwards rather than being horizontal as in normal situations.

أعِدَّ نفسَك؛ فلا تدري متى تُستعمَل.

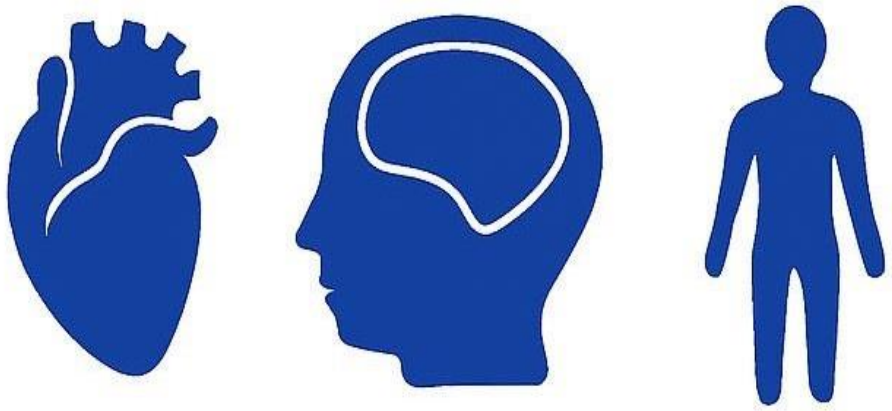
- الشيخ أحمد عبدالمنعم

Determine regularity



- Look at the R-R distances (using a caliper or markings on a pen or paper).
- Regular (are they equidistant apart)? Occasionally irregular? Regularly irregular? Irregularly irregular? Interpretation?

Regular



PHYSIOLOGY
QUIZ
LECTURE 5

External Resources

رسالة من الفريق العلمي

السلام عليك ياصاحبي
هوّن عليك فإن الأمور تجري بتقدير الله وكل أقدار الله خيرٌ وإن أوجعتك ..
يا صاحبي
إن الله يُدبرُ الأمور بحكمةٍ ورحمةٍ لا تخطر على بالنا لأننا قاصرو النظر ومحدودو التفكير ولا نرى من المشهد إلا بقعةً يسيرة فأما الله فيرى كل شيء...
يا صاحبي إذا ما تعلق الأمر بالله فتأدب...
إنه الله !
الغني عنك ولكنه لا يزهدُ فيك
والقوي الذي لا يحتاجك ولكنه يُناديك
أنسيت كل هذا ثم إذا أصابك من قدره ما لا تُحب بدأت تتذمرُ وتتأفف !
انتظِر دورة الأيام ستكشف لك حُجب الغيب وستعرف أنه ما أخذ منك إلا ليعطيك وما أصابك إلا ليرممك وما صرفك عن أمرٍ إلا لآخر هو خير لك منه!

والسلام لقلبك

Scan the QR code or click it for FEEDBACK

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	10&11 14&15	The images were reversed The explanation was inaccurate	Rearranged into the correct order Has been corrected
V1 → V2	20 / summary part 27	The scientists' names were reversed -	Has been corrected Chest leads positions