



## 3<sup>rd</sup> Lecture

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# The Electrocardiogram (ECG)

**Physiology Team - 430**

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**Abdulaziz Al-Nami** - Abdul Salam Baqays

Akeel Al-Mahdaly - Ali AL-Kahtani

Dalal Alqadi - Hanan AL-Amer

Hanoof AL-Khalaf - **Layan akkielah**

Lujayne Bukhari - **Reem Al jurayyad**

**Suliman AL-Shammari**

## The Electrocardiogram (ECG):

ECG is a test which records the **rhythm** and **electrical activity** of the heart. ECG is used to measure the rate and regularity of heartbeats, the size and position of the chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart.

ECG is **RECORDED** by the electrocardiograph (machine), which consists of electrodes. Electrodes are conductors through which an electric current enters or leaves a substance. ECG has a special paper and doesn't use the ink to write, it uses the heat to write. In one second ECG will write a paper at speed 25 mm.

### \*Notes :

Any depolarization going **toward** the electrodes reports **Positive** charge, If its going the **opposite direction** then it reports **negative**.

### The normal ECG :

**\*P wave → caused by Atrial depolarization (complete in 0.1 s).**

**\*Irregular or absent P waves may indicate arrhythmia.**

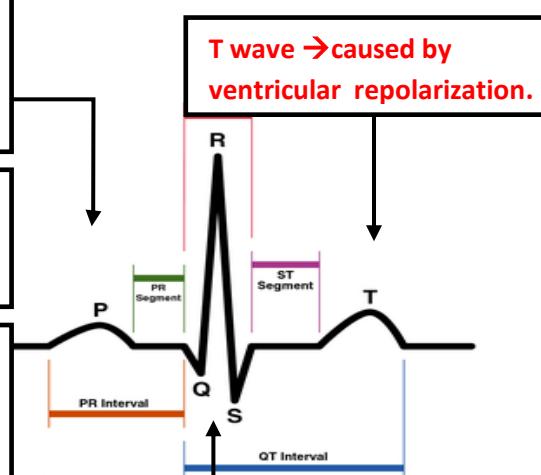
**\*The shape of the P waves may indicate atrial problems.**

**No atrial repolarization wave, Because atria repolarize during ventricular depolarization, so the wave is obscured by the large QRS complex.**

**\*QRS complex → caused by ventricular depolarization & atrial repolarization repolarization, between 0.08-0.1**

**\*Very wide and deep Q waves indicate myocardial infarction.**

**The U wave → repolarization of papillary muscle, can't be seen in older people and if we see it, it could be normal or in condition of hypokalemia (less K in the blood) & if a person's heart rate is less than 60 beats / minute.**

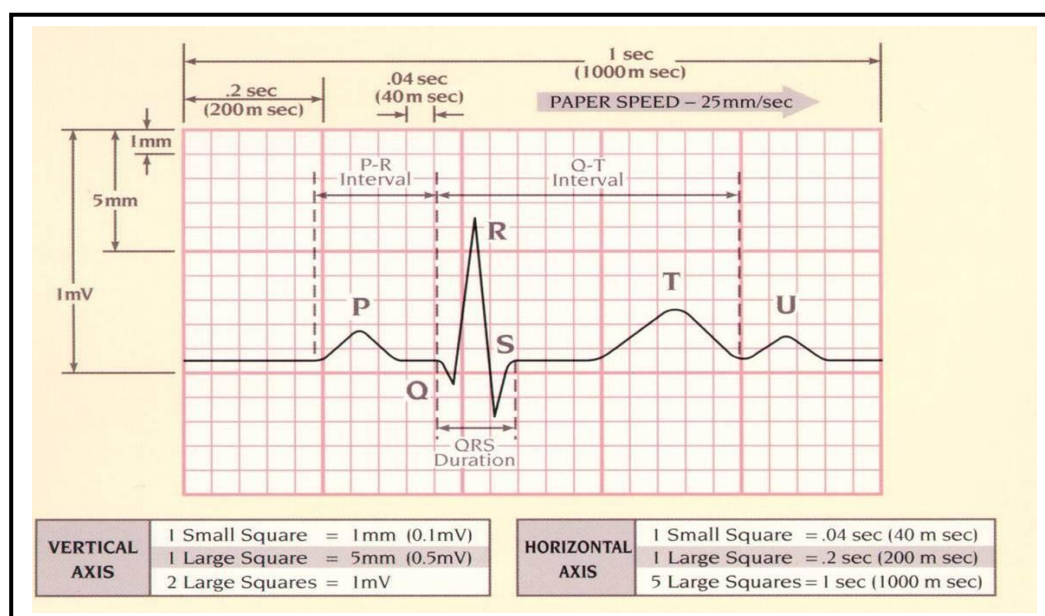


## Voltage and Calibration of the ECG :

\*The horizontal line which lies on the X axis represents the time

\*The vertical line which lies on the Y axis represents the voltage

- Horizontal lines :
  - 10 thin lines = 1 mV
- Vertical lines :
  - thin line=0.04 second
  - 5 small thin lines= 0.2 second
  - 1 inch= 1 second
  - 5 large squares = 1 inch = 1 second



## In normal ECG :

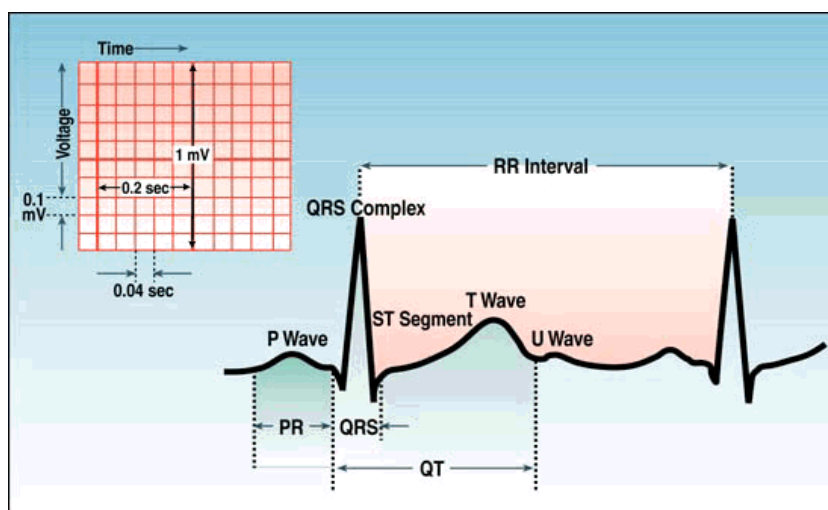
The amplitude of the ECG deflection reflects the mass of tissue involved.

P wave is smaller than the QRS complex , because the atrium's wall is thinner than the ventricle's wall ( reflects the mass of the tissue).

	Duration	voltage
T wave	A prolonged wave More duration ( repolarization extends over a long time )	Less than QRS complex
QRS complex	Less duration	More than T wave

## Practical Use of the ECG

### Normal Intervals on the ECG :



Segment	From - to	Cause	duration
P - R interval	beginning of P wave to beginning of Q wave	Atrial depolarization & conduction through AV node	<b>0.12 - 0.2 seconds</b>
Q - T interval	Beginning of Q wave to end of T wave	Electrical activity of ventricles	<b>Normal &lt;0.4 Or 0.44 seconds</b>
S - T segment	End of S wave to beginning of T wave	-----	<b>0.32 seconds</b>
R - R interval	Time between two consecutive R waves	-----	-----

\*\* between every two Rs is one impulse .

\*\*The importance of knowing PR interval:

To know the velocity of conducting system or how much time it takes to conduct from SA node up to ventricle .

If PR is 0.3 , it means conductive velocity is slow.

If there is heart block PR will be longer.

↑ heart rate → ↓ PR

## How to calculate the Heart Rate ( HR) :

Normal ECG paper has 300 large squares

HR is calculated by measuring the number of R waves per unit time.

Intervals between two thick vertical lines( 1 large square ) is 0.2 seconds so 5 large squares = 1 second , 30 large squares = 6 seconds  
OR 300 large squares in 1 minute → to calculate heart rate you divide 300 over the number of large squares between the R waves .

$$\frac{300}{\text{The number of large squares between R waves}} = \text{regular heart rate}$$

Irregular heart rate is calculated in a different way .

\*If you had the complete paper of ECG, you see the number of R waves and multiply it by 5 . \*If you didn't have the full ECG, you count 30 large squares and you see the number of R waves in this 30 large squares then u multiply it by 10 .

## Flow of Electrical current in the Heart :

The first area that depolarizes is the ventricular septum then shortly spreads to the inside of the ventricles.

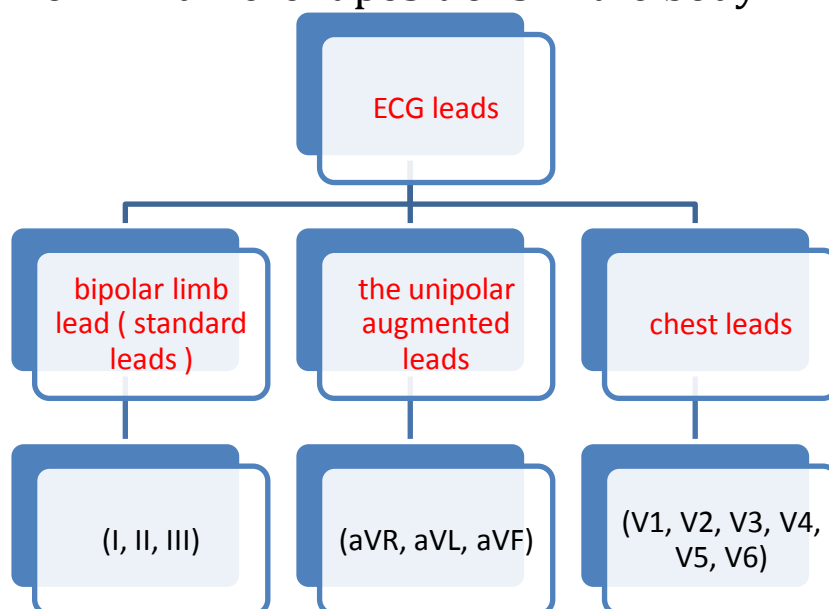
During depolarization, the electrical current flows from the base of the heart (negative) toward the apex (positive).

The electrodes Near the base is -ve, and near the apex is +ve.

## The ECG Leads :

Lead: two wires and their electrodes to make a complete circuits.

ECG is taken from 12 different positions in the body.



\*Bipolar means two electrode active placed in two different positions , one positive and the other negative . They can't have the same charge ( ++ or -- ).

\*Unipolar means one recording electrode active and another at zero potential .

### ECG leads :

1- The standard limb lead : has three positions I,II and III .

The electrocardiogram is recorded from two electrodes,

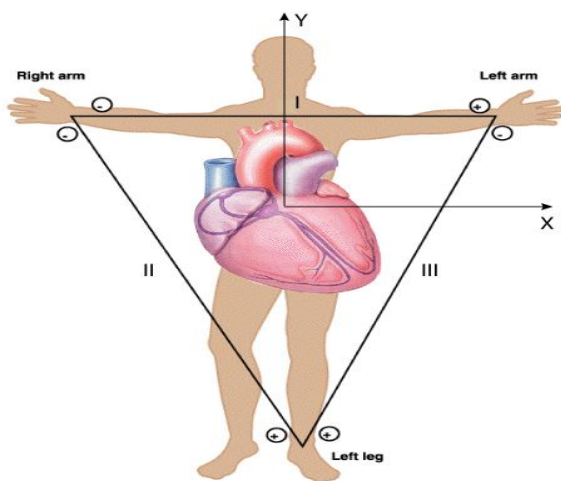
- lead I : When we connect tow electrode in the both arms ,right arm negative electrode and the left arm is positive.
- Lead II : we connect the right arm (negative charge), and the left leg (positive charge).
- Lead III : left arm (negative) and left leg (positive).



## Einthoven's Triangle:

- Einthoven's Triangles drawn around the area of the heart ( triangle with equal angles ).
- **Einthoven's law** :  
if the electrical potential of two of the standard limb leads are known , the third one can be determined mathematically by summing the two together .

Example: sum of electrical potential of lead I and III = electrical potential of lead II (lead I + lead III = lead II) .



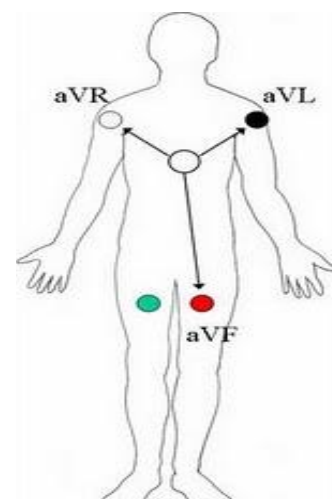
\*The heart at the center and we place all its angles at the limbs except the right leg.

\*Why we don't place an angle in the right leg inserted of left leg?  
Because the heart tend to be in the left side.

## 2- The augmented unipolar limb leads : aVR, aVL, aVF

It is a unipolar so one electrode active and the other inactive = zero (apex of the heart)

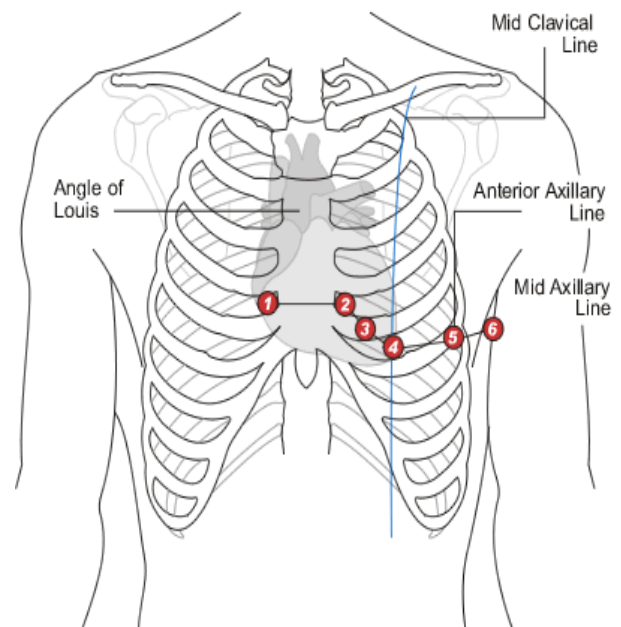
- **aVR**: the active electrode connected to the right arm while the inactive electrode at the apex of the heart .
- **aVL**: the active electrode connected to the left arm while the inactive electrode at the apex of the heart .
- **aVF**: the active electrode connected to the left leg while the inactive electrode at the apex of the heart .



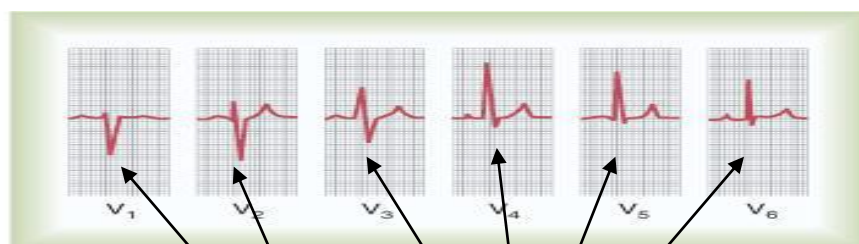
### 3- Chest leads : (V1, V2, V3, V4, V5, V6)

- one electrode is placed on the anterior surface of the chest on one of the points shown (positive)

\*V1: 4<sup>th</sup> intercostal space, just right of sternum  
 \*V2: 4<sup>th</sup> intercostal space, just left of sternum  
 \*V1 and V2 record from right ventricle  
 \*V4: 5<sup>th</sup> intercostal space in the mid clavical line (at the apex of the heart)  
 \*V3: mid way between V4 & V2  
 \*V4 & V3 are variable because V3 depends on location of V4 and V4 depends on the apex , the apex location is different from person to another.  
 \*V5: At the same level as V4 but in the anterior axillary line.  
 \*V6: At the same level as V5 in the mid axillary line.  
 \*V5 & V6 record from lateral part of the body.



- V1 and V2 QRS are mainly **negative** because the chest leads are closer to the base of the heart
- V3,V4, V5and V6 are mainly **positive** because the chest electrode are closer to the apex .



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Negative

Positive



## Cardiac axis:

The ECG can be used to identify the direction of travel of the wave of depolarization through the heart.

The electrical potential can be represented by a vector, with the arrowhead pointing in the positive direction.

**The length of the vector is proportional to the voltage**

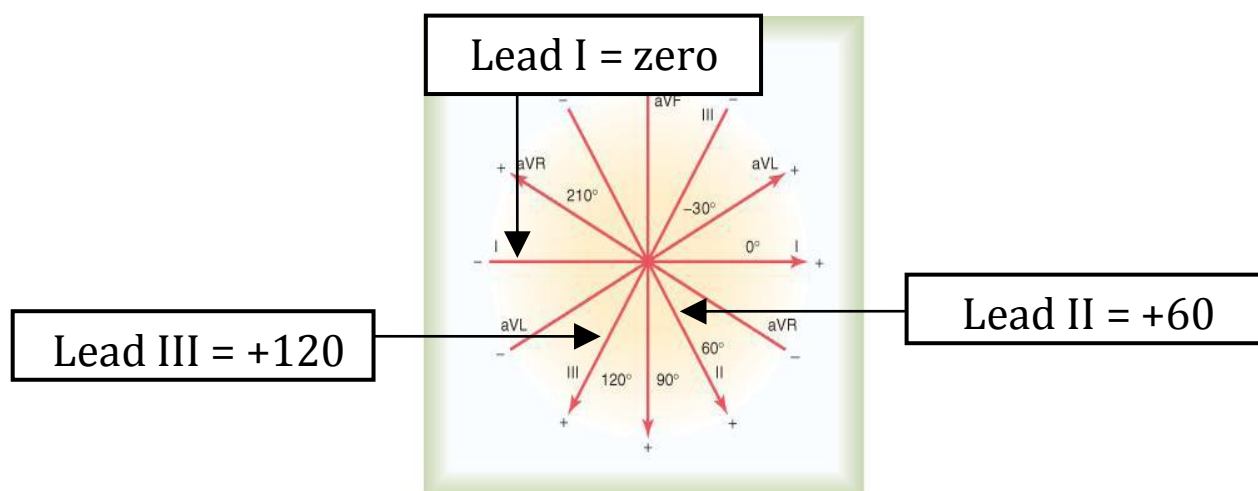
**When the vector is horizontal and points toward the left side, the axis is zero → lead I**

If the vector moves **Downwards +90 (clockwise)**

If it moves **upwards -90 (counterclockwise)**

Counter clockwise → negative

Clockwise → positive



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## How to calculate the cardiac axis :

### A) Using your thumb:

You should have the ECG paper and You will look mainly at the QRS complex in Lead I & Lead III. But first determine which thumb is for lead I and which is for lead III.

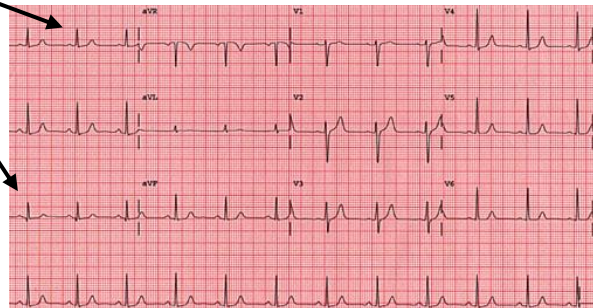
Then see the QRS complex in lead I, check if it positive (upwards) or negative (downwards) .

If it was positive , You will place your thumb upward and so on .

This way , you will have one of the three results below :

### 1 - normal phase :

Both lead I & lead III are **positive** ,therefore both your thumbs will be directed upwards

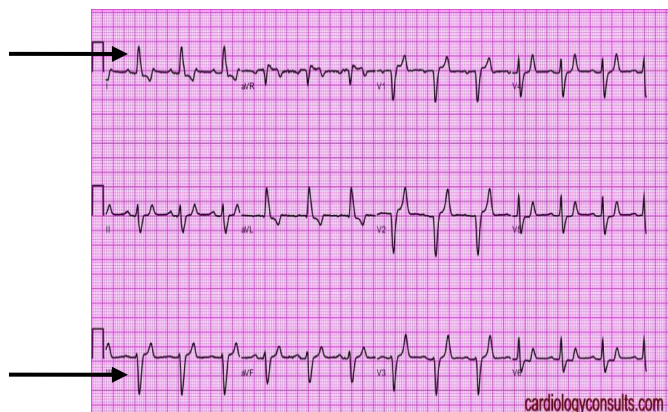


Normal cardiac axis is usually within  $-30$  to  $+90$

### 2 - left axis deviation :

Also called (divorce phase)

Lead I will be **positive** but lead III will be **negative** , therefore your thumbs will be in opposite directions.



### Causes of left axis deviation :

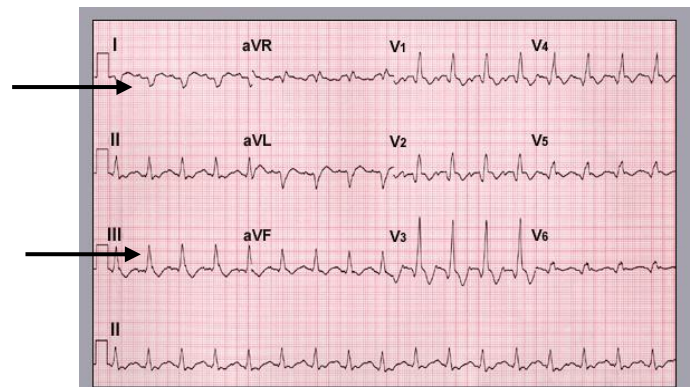
- Left bundle branch block block :  
In this condition, activation of the left ventricle is delayed, which results in the left ventricle contracting later than the right ventricle.
- Left ventricular hypertrophy (hypertension).

### 3- right axis deviation :

also called (kiss phase) .

Lead I will be **negative** But lead III will be **positive** .

The thumbs will meet.



### Causes of right axis deviation :

- Right bundle branch block:  
During a right bundle branch block, the right ventricle is not directly activated by impulses travelling through the right bundle branch. It is activated by the impulses that travel through the myocardium from the left ventricle .
- Acute myocardial infarction.
- Ischemia : is a restriction in blood supply

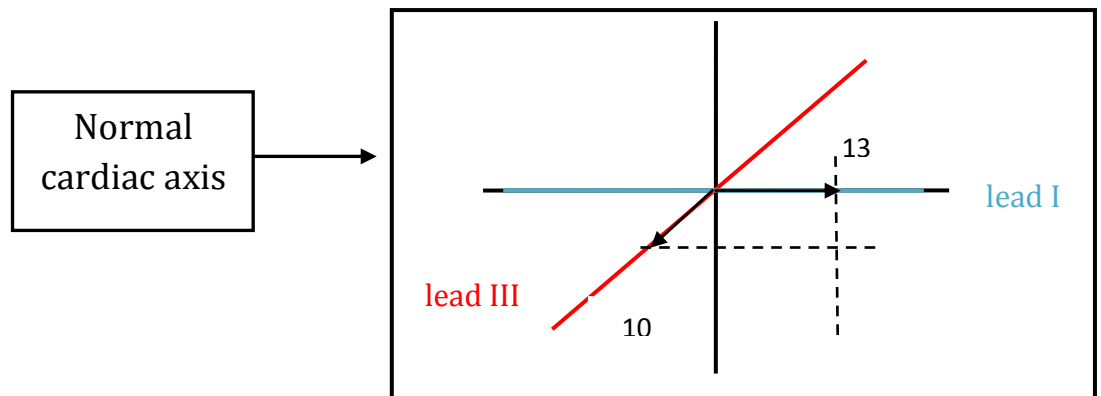
## B) tri – Hexial system :

- \* draw Lead I .
- \* draw lead III at the center of lead I as the picture below .
- \* R- S : look at the ECG paper & count the small squares that are above the zero line (R wave) and the small squares that are below the zero line (S wave) , take in consideration the signs ( positive and negative ) then add them and you will find lead I and do the same for lead III .

For example RS in Lead I =  $13 - 0 = 13$

RS in lead III =  $10 - 0 = 10$

- \* Draw a perpendicular line on each point
- \* the intersection of both perpendicular lines is the cardiac axis
- \* If it was in the fourth quarter it means the cardiac axis is normal.  
If it was in the first quarter it means that there is left axis deviation.  
If it was in the third quarter it means that there is right axis deviation



**Good Luck**