Beginner's Guide To

Frontal Plane

Axis Determination

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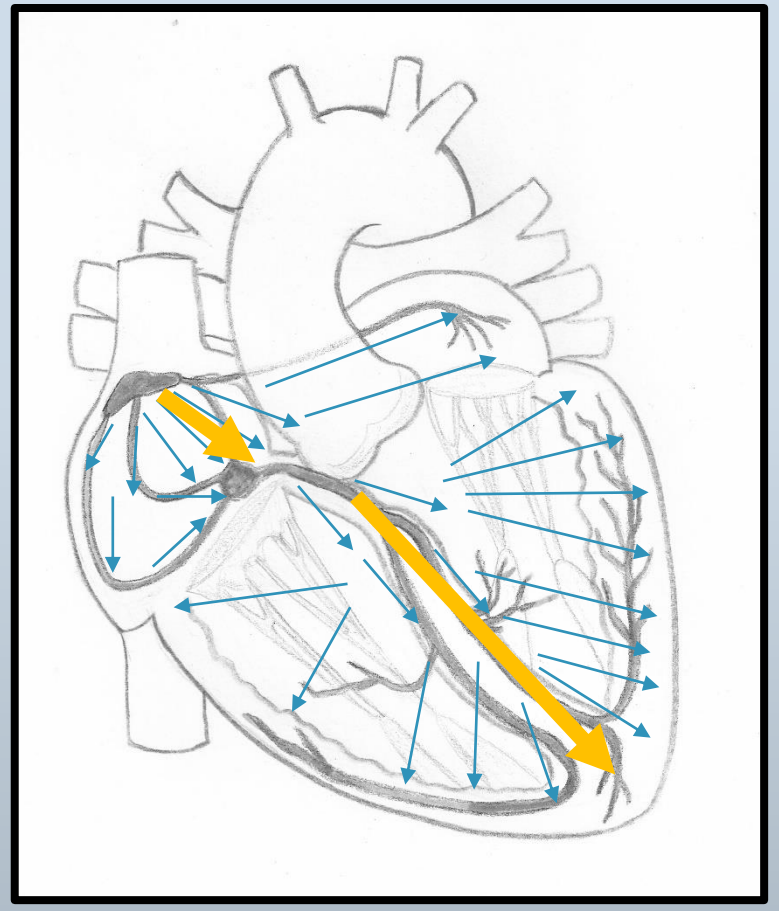
So what is “frontal plane axis?”



- **The frontal plane electrical axis is a representation of the “MEAN”, or AVERAGE direction of all the electrical forces in the heart.**
- **The yellow arrows represent the P wave axis and the QRS axis.**

Why Would We Care What The Axis Is?

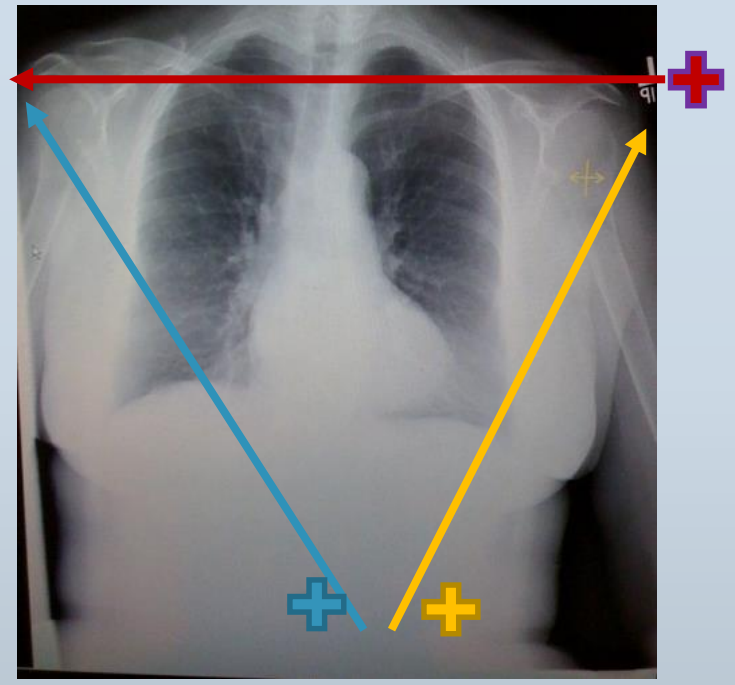
- Generally speaking, you don't need to know the axis MOST of the time. Especially when it is NORMAL.
- Knowing how to plot the axis can help you determine that an ECG is normal – and we should always be able to recognize normal before we attempt to determine what is abnormal.
- Recognizing an abnormal axis can help you diagnose: Hemiblocks, Junctional Rhythms, and Ventricular Tachycardia.
- People who understand axis understand ECG better – they are more "fluent" (an editorial opinion from the author!)

- We use the frontal plane leads to determine the general direction of electrical activity through the heart with respect to left/right and up/down.

- The frontal plane leads are I, II, III, aVR, aVL, and aVF, also called the LIMB LEADS.

- We can also determine direction in a front/back orientation using the CHEST LEADS. For now, we will discuss only FRONTAL PLANE AXIS DETERMINATION.

Frontal Plane Leads



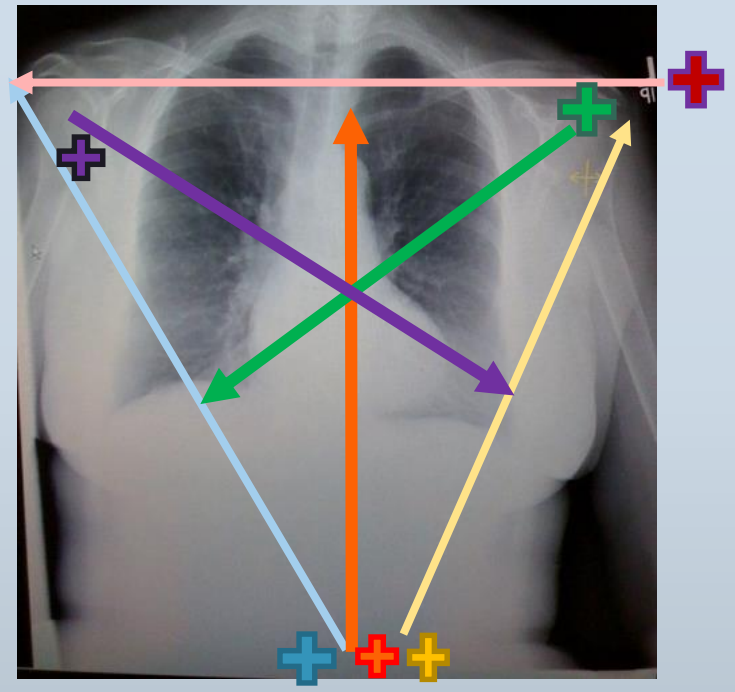
- The viewpoints of the six limb leads are from left to right, right to left, top to bottom, or bottom to top. (Remember, it is the PATIENT'S left and right.)

Lead I "looks at" the heart from the left arm toward the right arm. The positive, or recording, electrode is on the LEFT ARM, looking toward the right arm electrode.

Lead II "looks at" the heart from the left leg toward the right arm. The recording electrode is on the LEFT LEG. looking toward the right arm electrode.

Lead III "looks at" the heart from the left leg toward the left arm. The recording electrode is on the LEFT LEG, looking toward the left arm electrode.

Frontal Plane Leads (cont'd.)



- The viewpoints of the six limb leads are from left to right, right to left, top to bottom, or bottom to top.

aVF "looks at" the heart from the left leg, toward both the arm electrodes. The recording electrode is on the **LEFT LEG**, looking toward the midpoint between the arms.

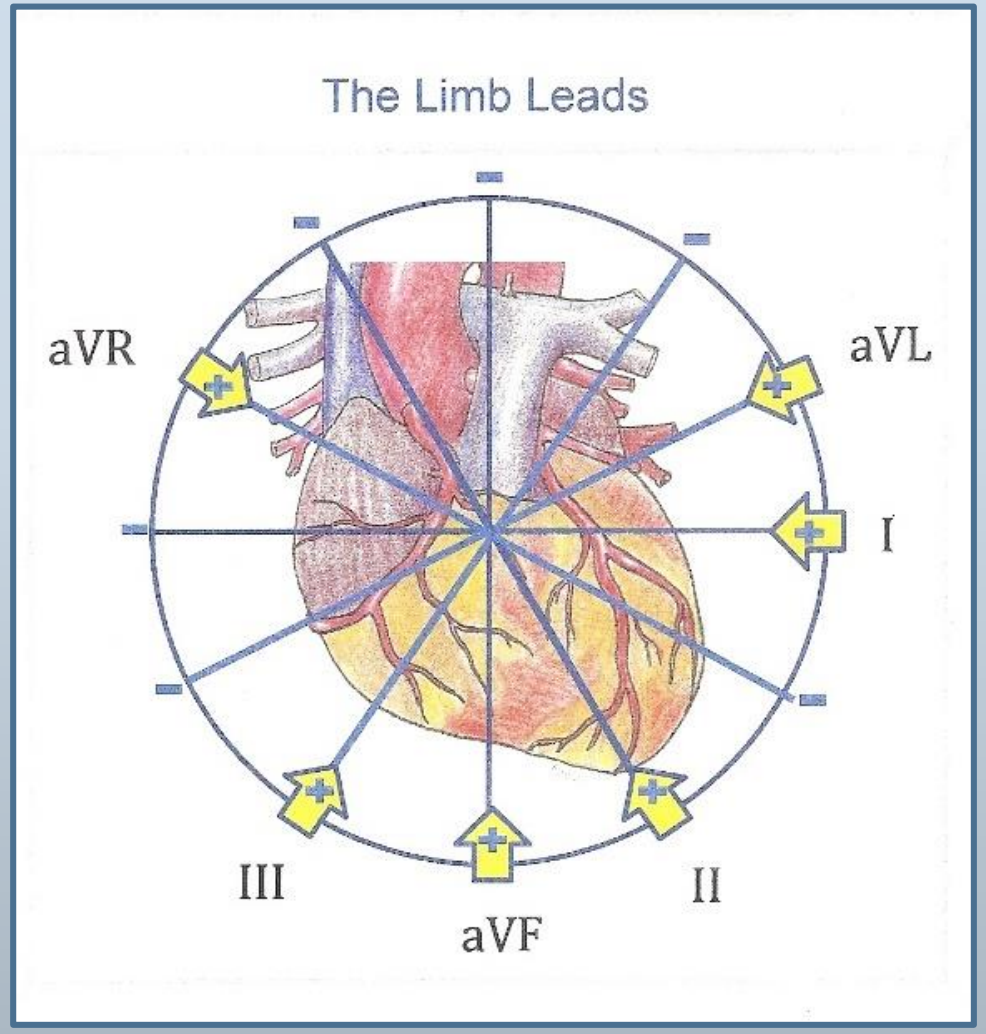
aVL "looks at" the heart from the left arm, toward the RA and LL. The recording electrode is on the **LEFT ARM**, looking toward the midpoint between the RA and LL.

aVR "looks at" the heart from the right arm, toward both the LL and LA. The recording electrode is on the **RIGHT ARM**, looking toward the midpoint between the LL and LA.

Frontal Plane Leads

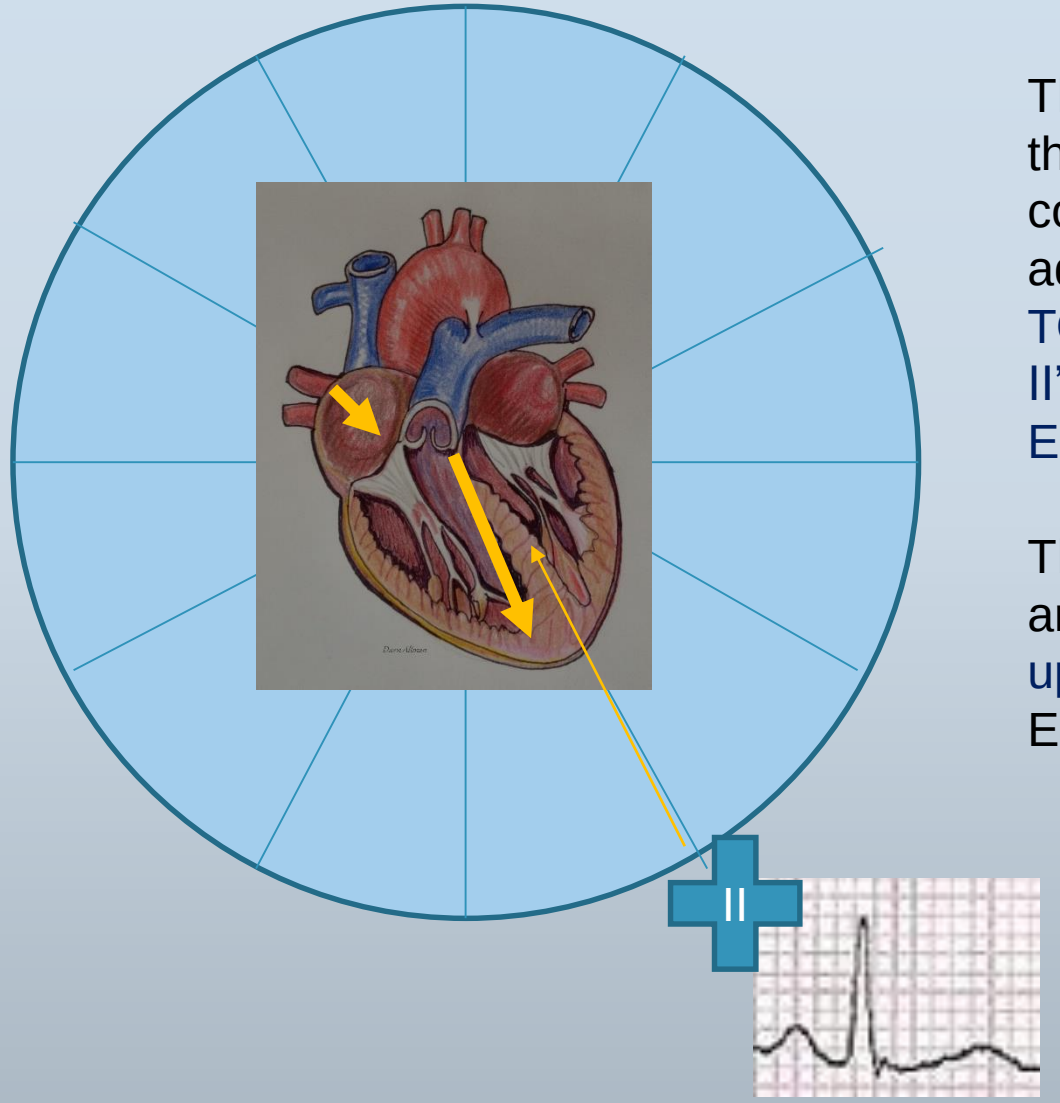
Using the Hexaxial Reference System

- The ECG machine interprets the leads of the frontal plane on this circle.
- It is all done with math, and it's better for you to forget triangles, and practice seeing the leads arranged on this circle.
- Each lead passes through the center, and there is a positive OR negative pole every thirty degrees on the circle.



There is an important principle in ECG that tells us:

When a wave of depolarization advances TOWARD a positive pole of a lead, THAT LEAD will record an upright, or positive wave

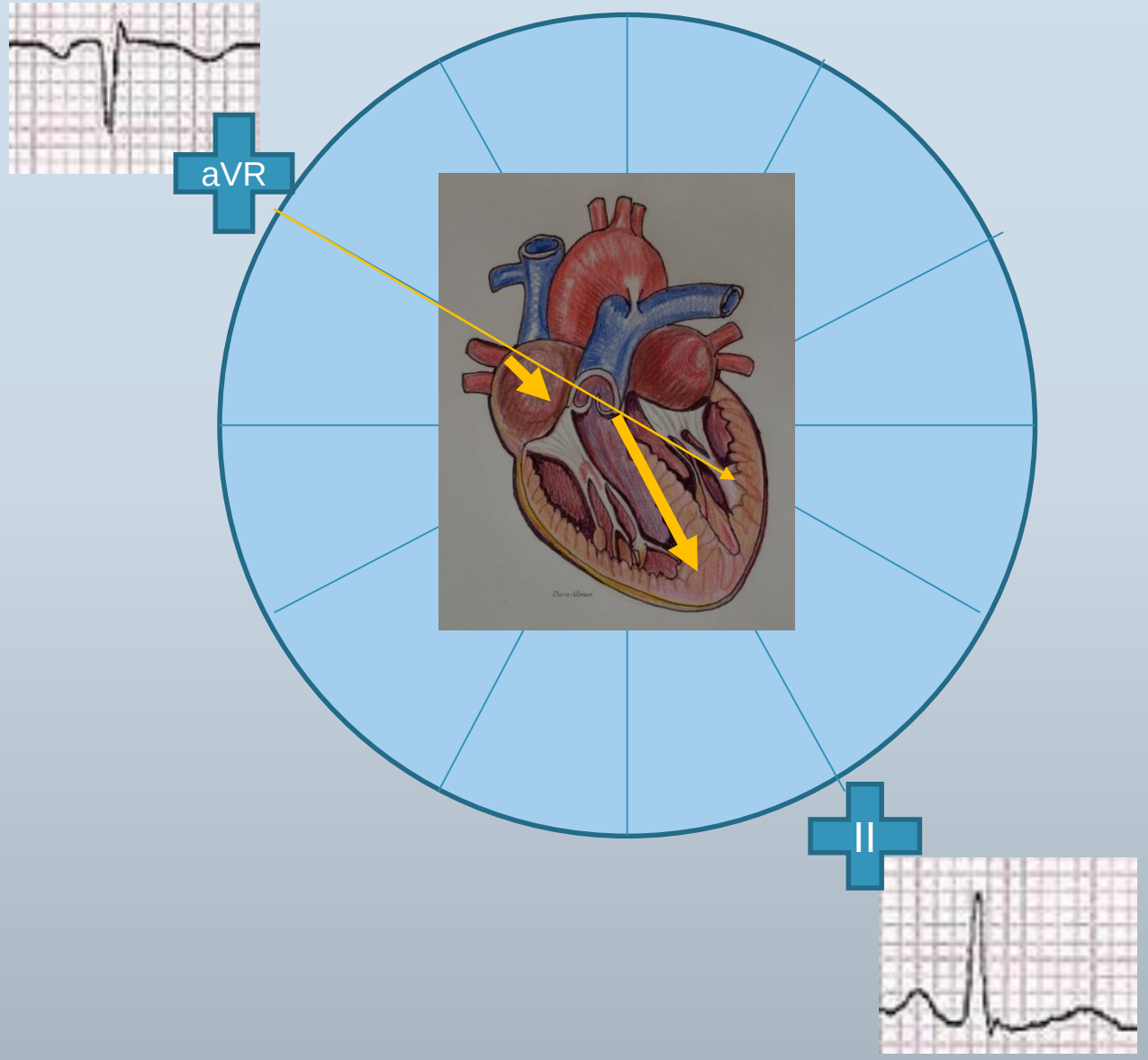


The P wave AND the QRS complex are both advancing TOWARD Lead II's POSITIVE ELECTRODE.

This makes the P and the QRS upright on the ECG.

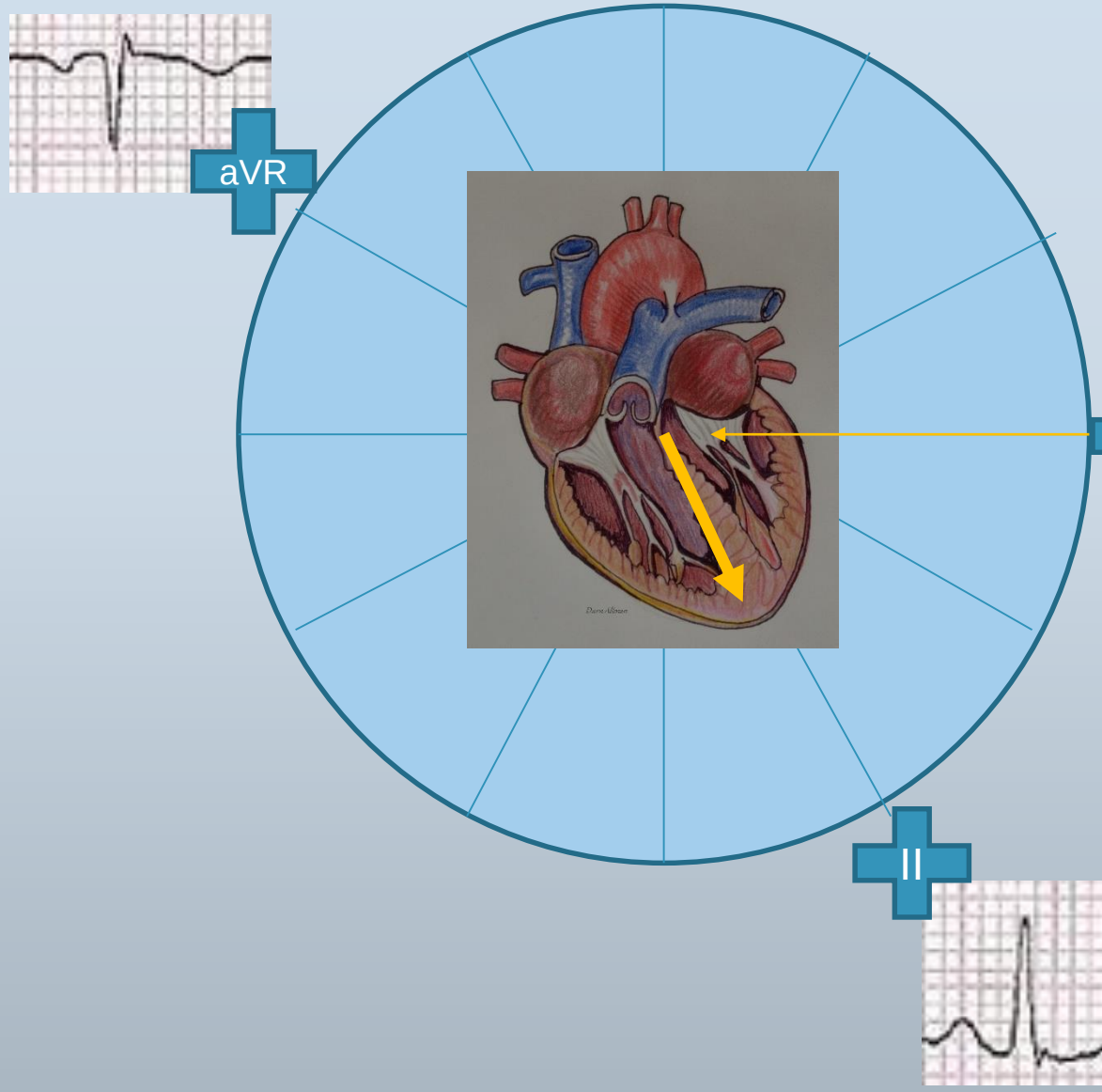
In aVR, the P wave and the QRS complex are traveling AWAY FROM the lead's posiltive electrode, so they are negative.

The other half of that principle states that electricity flowing AWAY from the positive electrode will produce a negative deflection.



The more DIRECTLY the impulse travels toward the positive electrode, the taller the wave will be.

Let's focus on the QRS complex for a while to study these points.

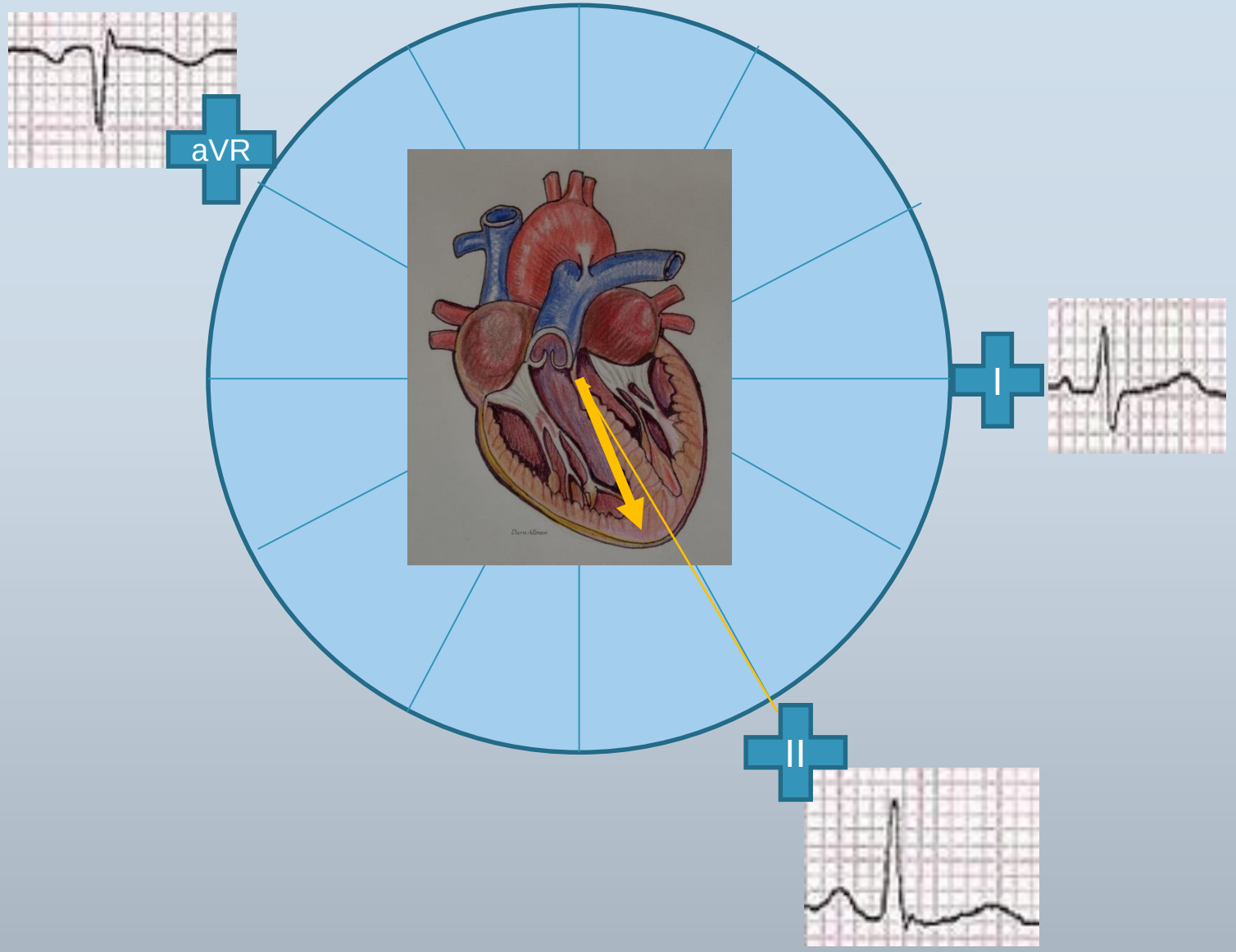


Lead I has a QRS that is still MOSTLY positive (subtract the number of small boxes that are below the line from the number of small boxes above the line).

But Lead I's positivity is **less than** Lead II's.

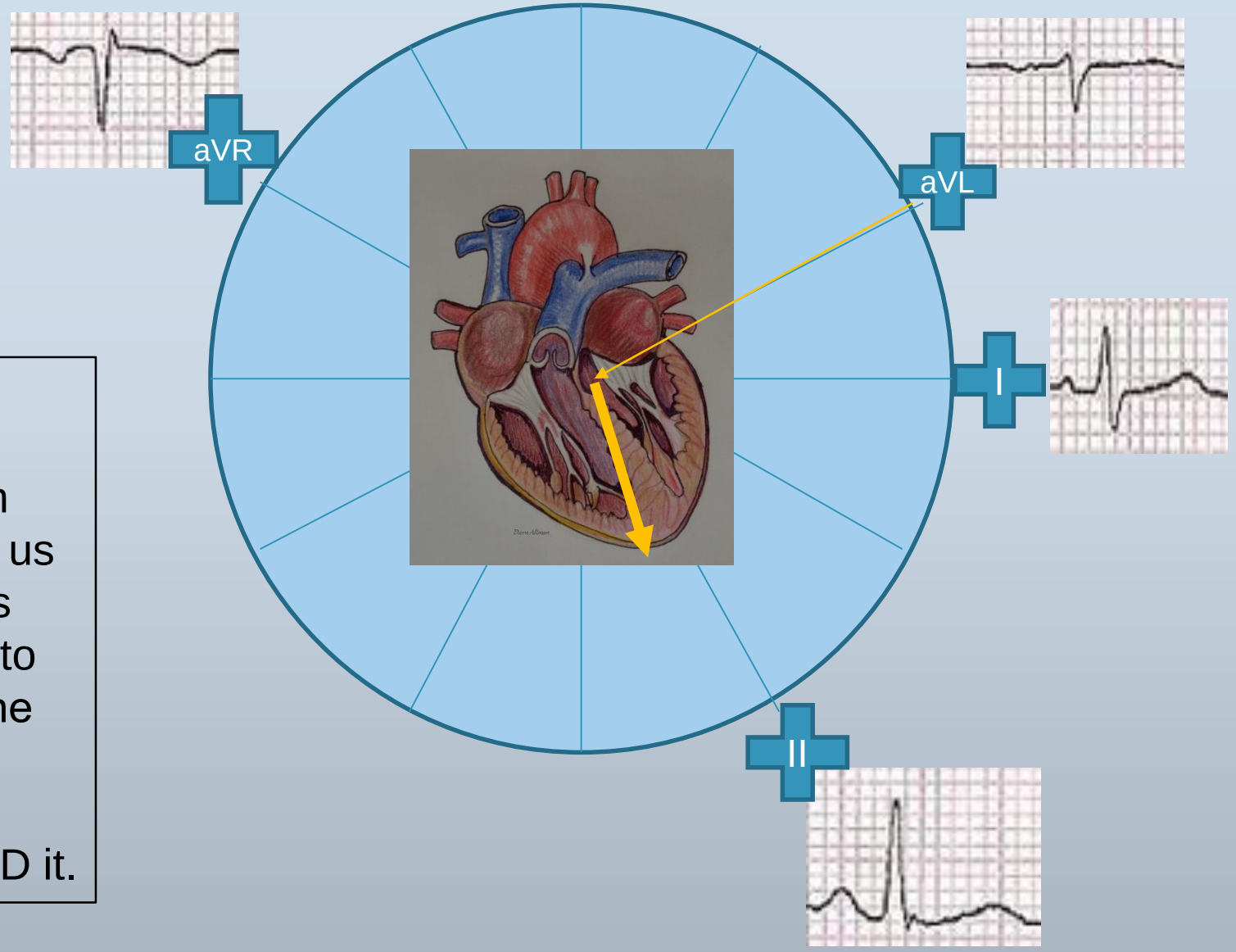
Looking at this example from a real ECG, do you think you could say that the ventricles' AXIS (direction of electrical flow) is travelling toward Lead II?

And would you agree that Lead II has the tallest upright QRS (R wave) so far?

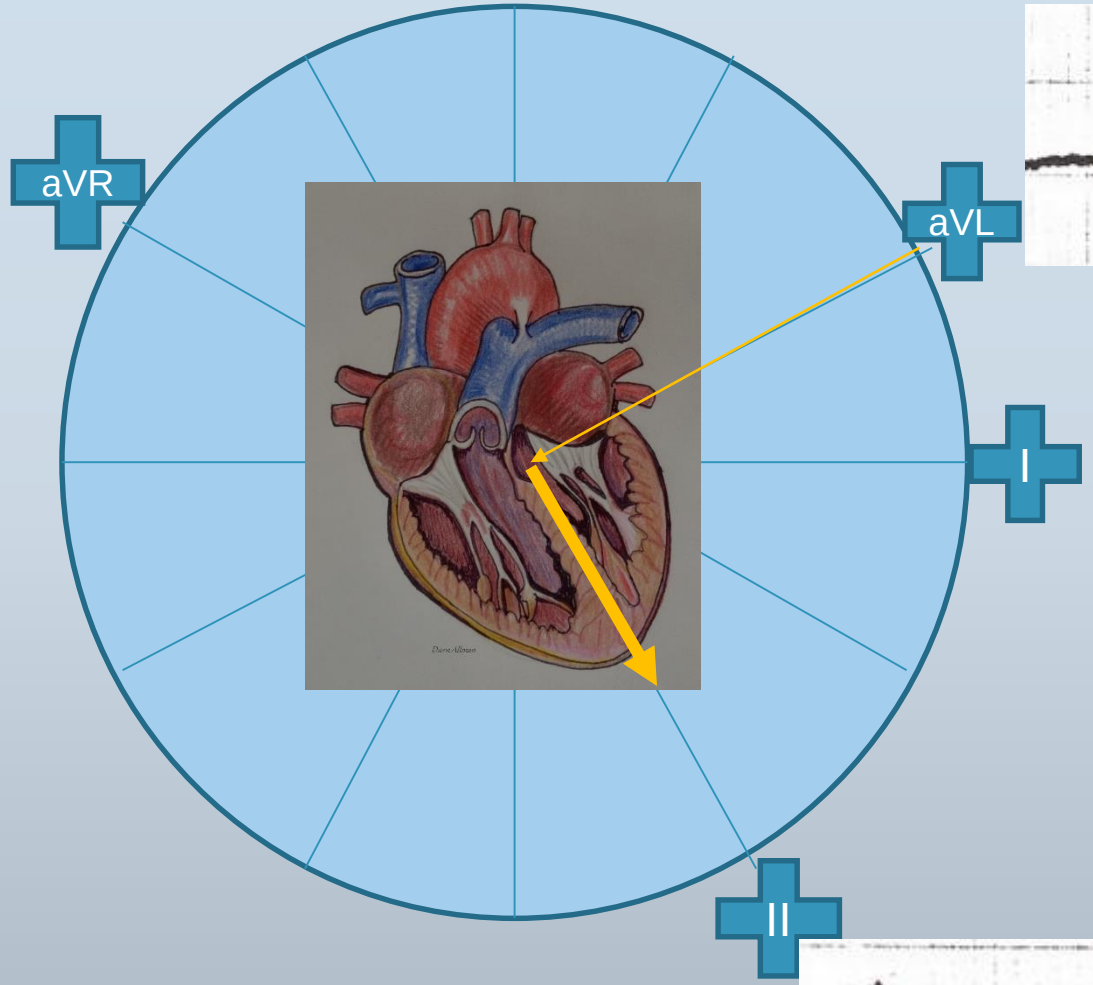


What do you think will happen when the lead you use lies nearly PERPENDICULAR to the heart's electrical axis?

aVL is very small and about 2 small blocks more NEGATIVE than POSITIVE. That tells us that aVL's viewpoint is almost perpendicular to the heart's axis, but the axis is flowing more AWAY from aVL's positive than TOWARD it.



When we view a lead that is exactly perpendicular to the heart's axis, we get an equiphasic QRS – there are equal amounts of the QRS above and below the isoelectric line.

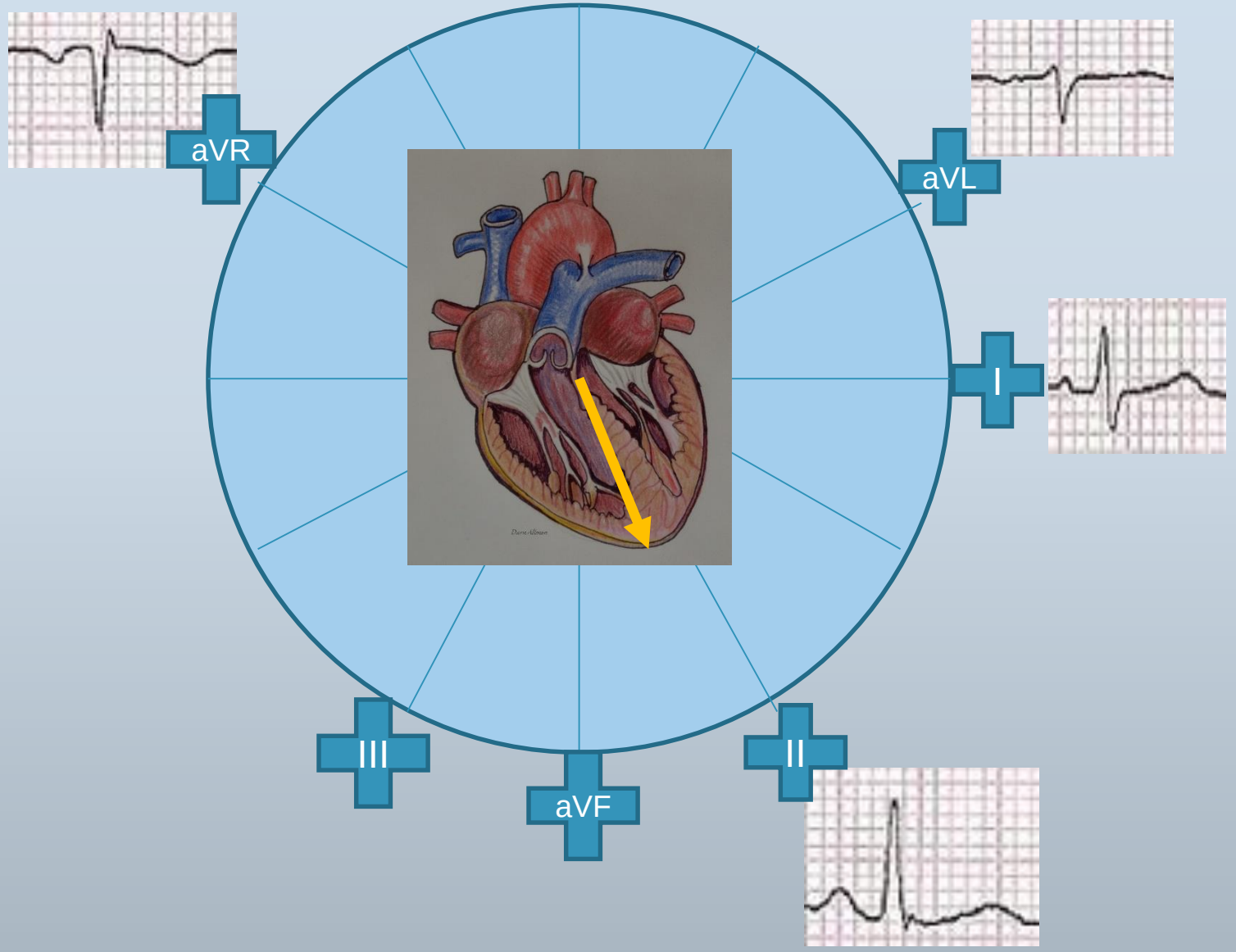


It is even possible in certain circumstances to see a FLAT LINE.

Always check in two or more leads if you see a flat line.

Knowing what you know now, try to predict what the QRS complexes in III and aVF will look like:

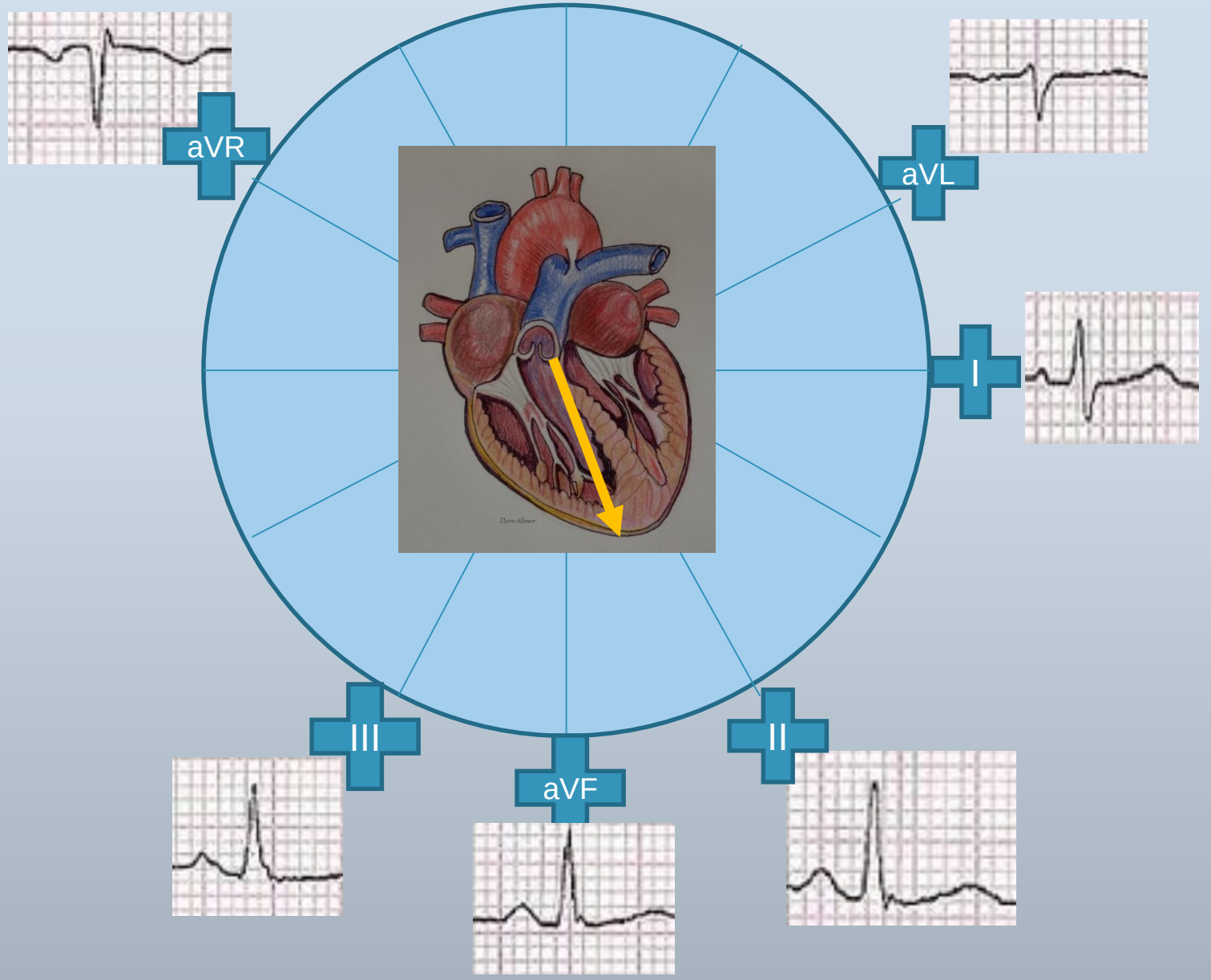
Negative, positive, equiphasic, tall, short?



How did you do?

Lead III is upright, but not as tall as Lead II. aVF is a hybrid between II and III.

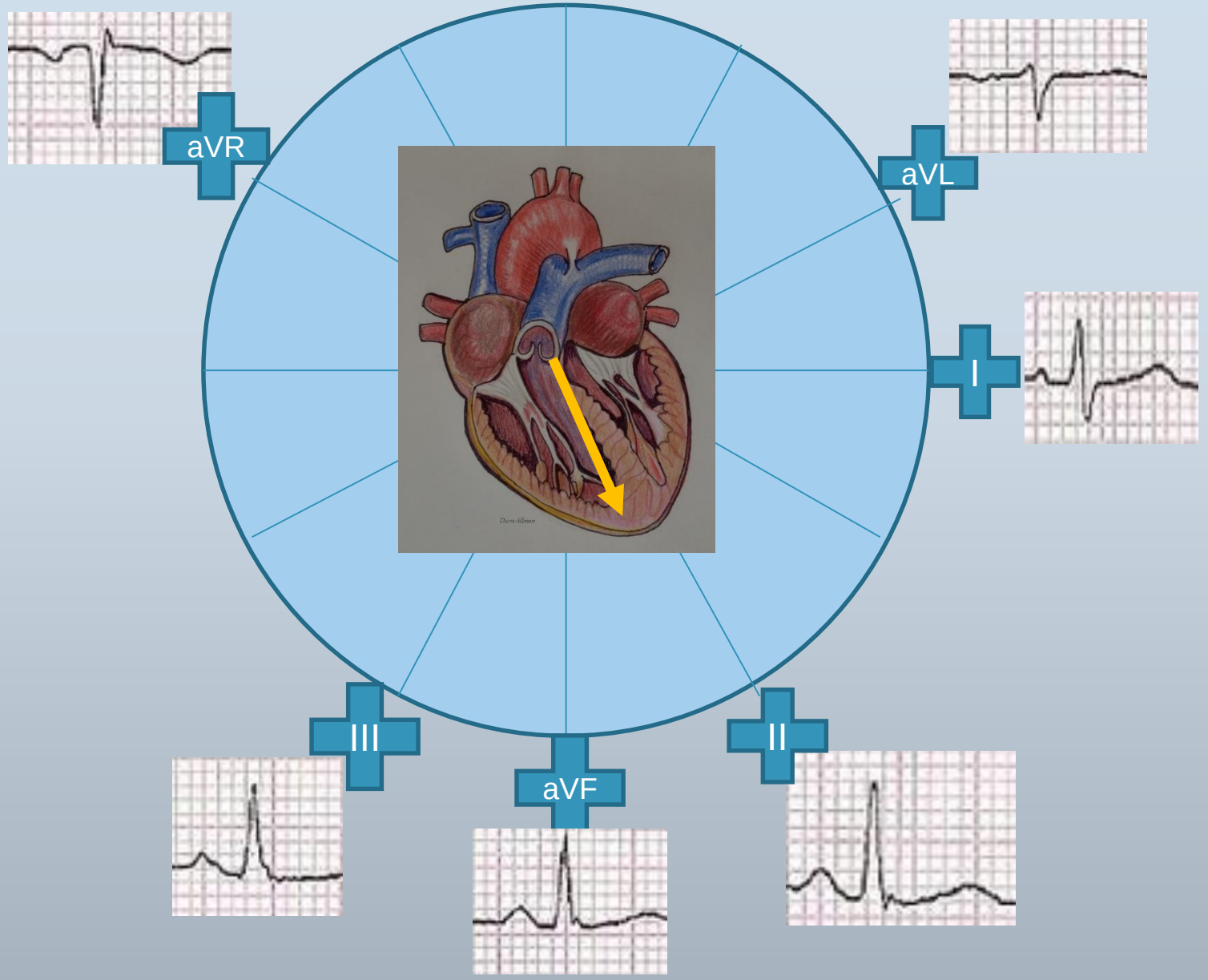
All of the INFERIOR leads, which originate on the left leg, are POSITIVE in this example. Their positive electrodes are “in front” of the wave of electricity.



So, from what you see here, would you agree with the statement, “The electrical axis points toward the lead with the tallest R wave”?

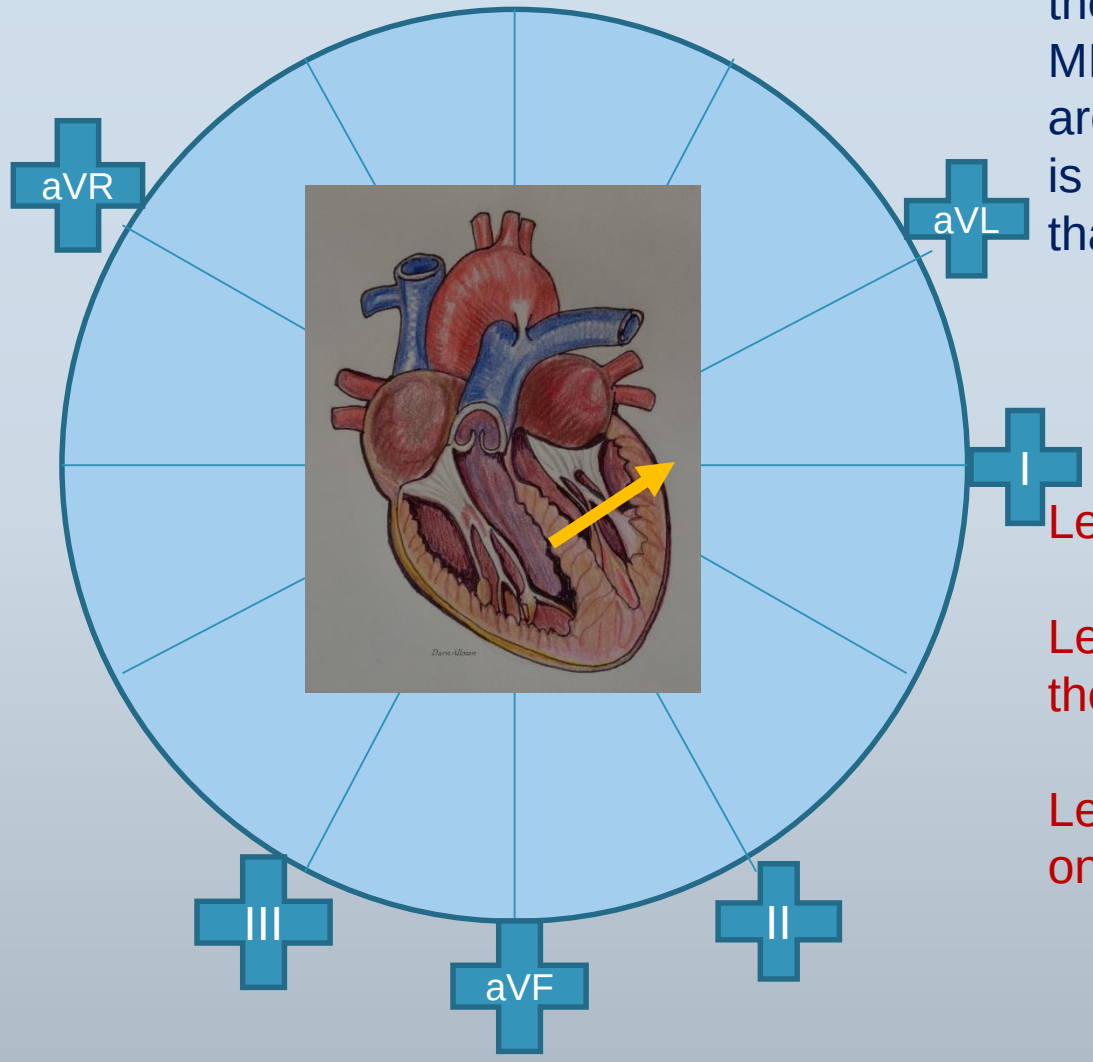
That is correct. It’s not THAT complicated after all.

(The axis ALSO points AWAY from the lead with the deepest S wave.)



What if our patient has a VERY LARGE left ventricle? There is much more muscle mass on the left that the right. The mean, or average, of all the electrical energy now travels more leftward.

NOT ALL PEOPLE WITH LEFT VENTRICULAR HYPERTROPHY HAVE AN AXIS SHIFT, BUT THIS ONE DOES.



(Remember, the heart is tilted to the LEFT in the body – so the MIDDLE of the heart is around Lead II. LEFT is actually HIGHER than RIGHT.

Lead II is the CENTER

Leads I and aVL are on the LEFT

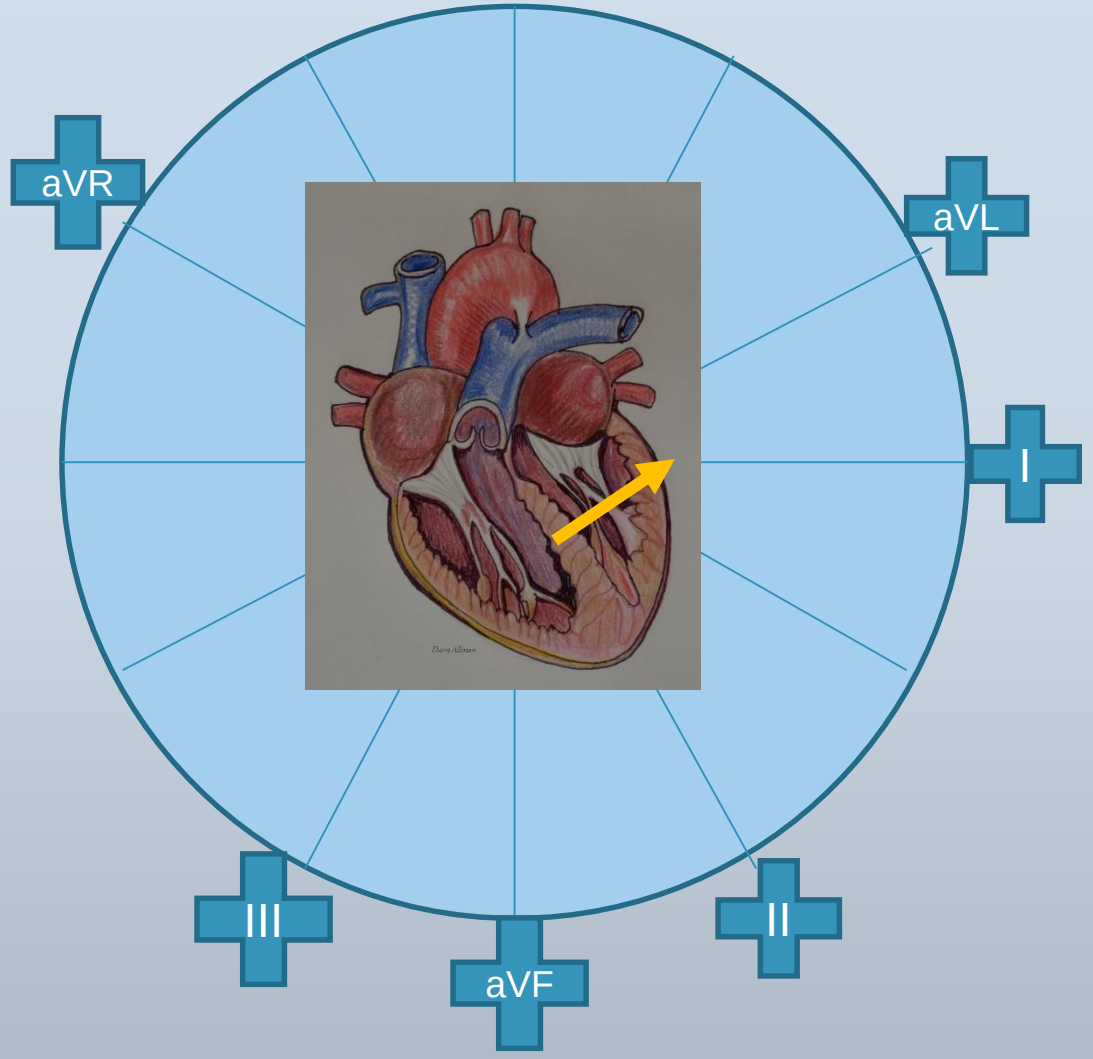
Leads avF and III are on the RIGHT.

For THIS patient, which lead would you expect to have the TALLEST R WAVE?

Lead II is the **CENTER**

Leads I and aVL are on the **LEFT**

Leads avF and III are on the **RIGHT**



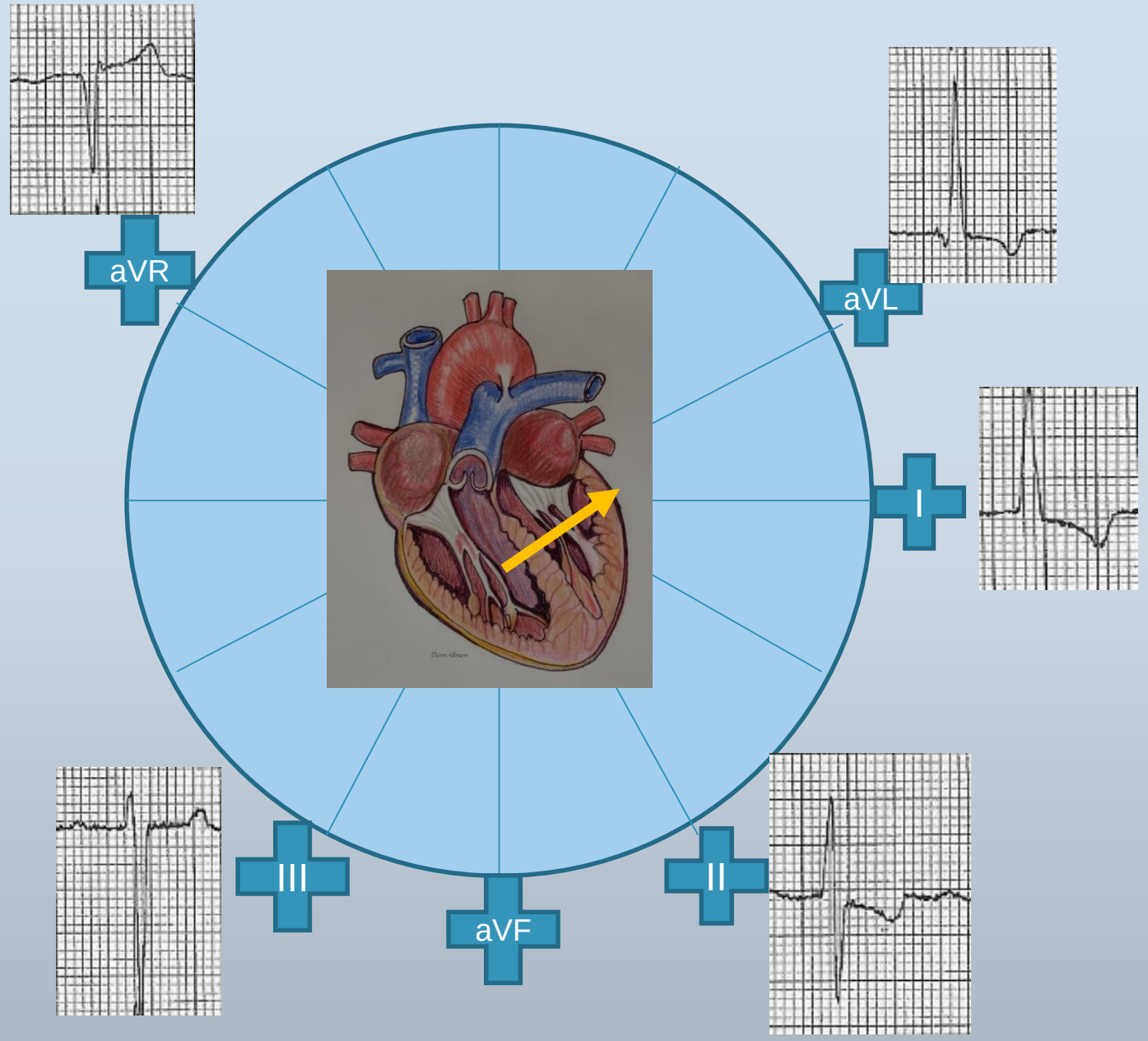
For THIS patient, which lead would you expect to have the TALLEST R WAVE?

Lead II is the **CENTER**

Leads I and aVL are on the **LEFT**

Leads avF and III are on the **RIGHT**

The TALLEST UPRIGHT QRS is aVL and the DEEPEST NEGATIVE QRS is Lead III.



Lead II is the **CENTER**

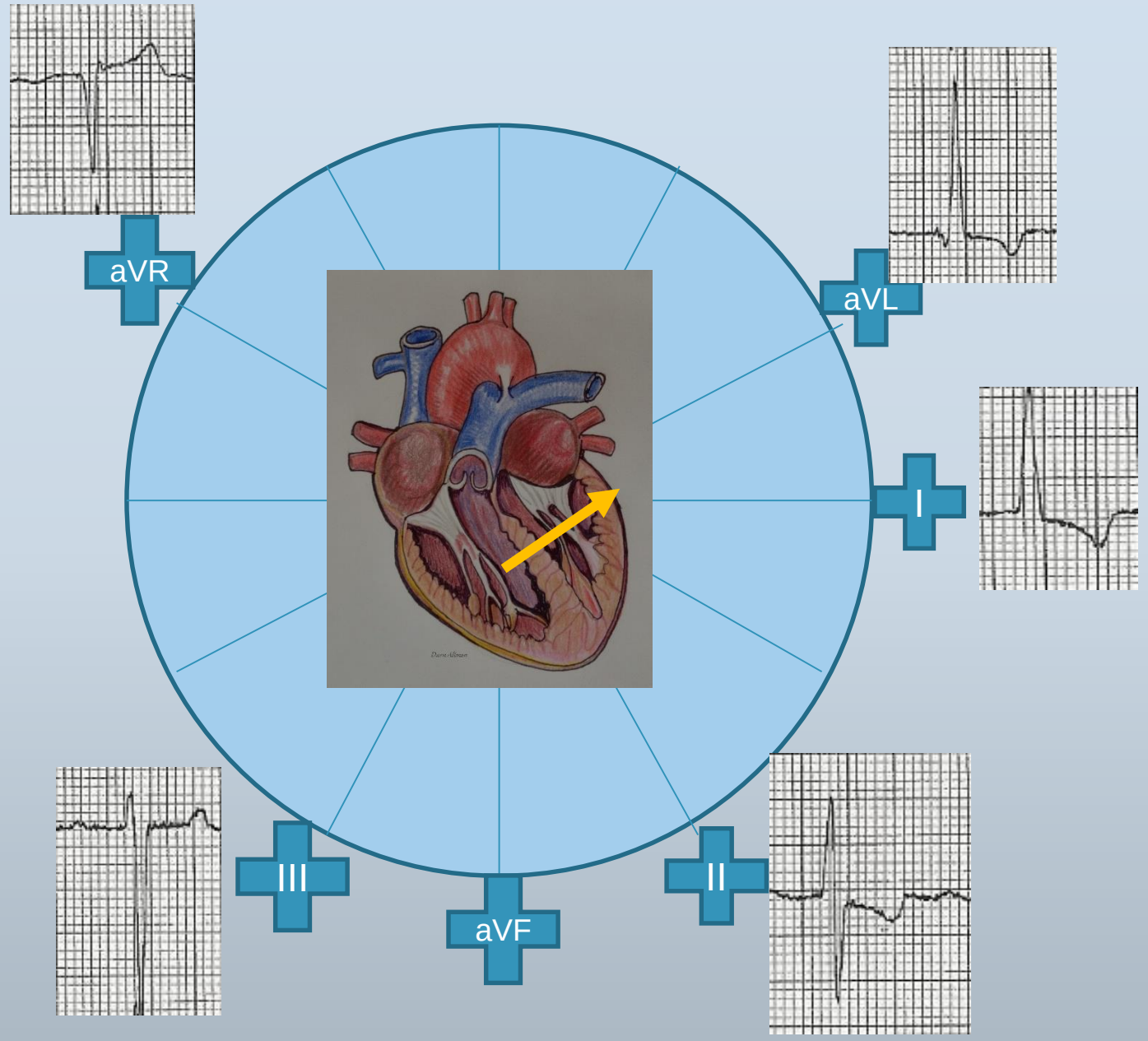
Leads I and aVL are on the **LEFT**

Leads avF and III are on the **RIGHT**

The TALLEST UPRIGHT QRS is aVL and the DEEPEST NEGATIVE QRS is Lead III.

DID YOU NOTICE THAT LEAD II IS EQUALLY BIPHASIC? It is perpendicular to the heart's AXIS.

It is not so small, because of the patient's left ventricular hypertrophy.

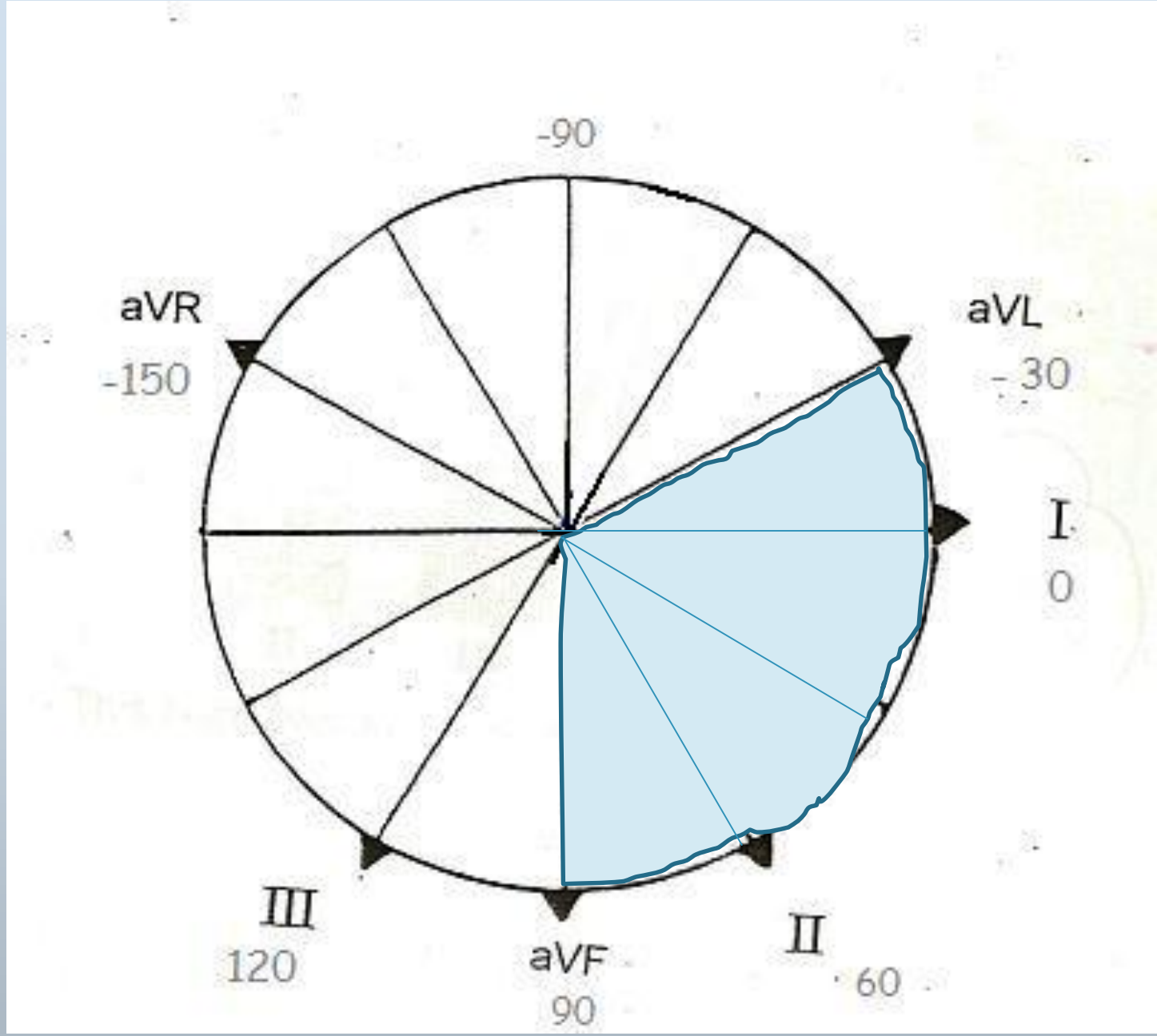


This is the area that is considered to represent a NORMAL QRS axis.

Between -30 degrees and 90 degrees is normal.

There is much variation between individuals.

Even changing your position can change the axis of your heart on ECG, as the heart hangs in the chest more vertically when you are upright, and more horizontally when you lie down.



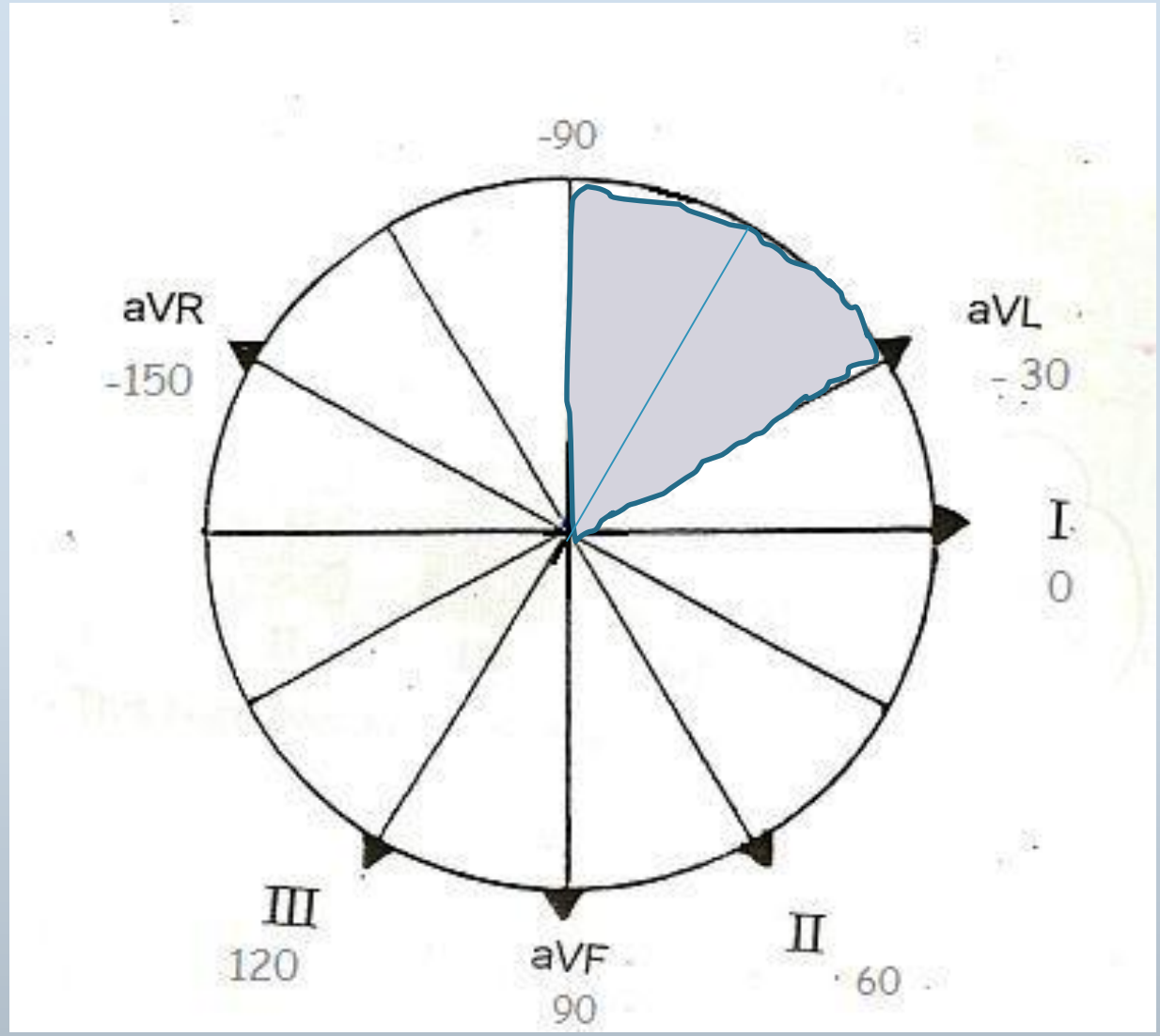
This is the part of the circle that is considered to be "Left Axis Deviation"

-30 degrees to -90 degrees.

Remember, the LEFT side of the heart is high – under the left armpit.

Question:

What do you think Leads II, III, and aVF will look like if the axis is deviated to the left?



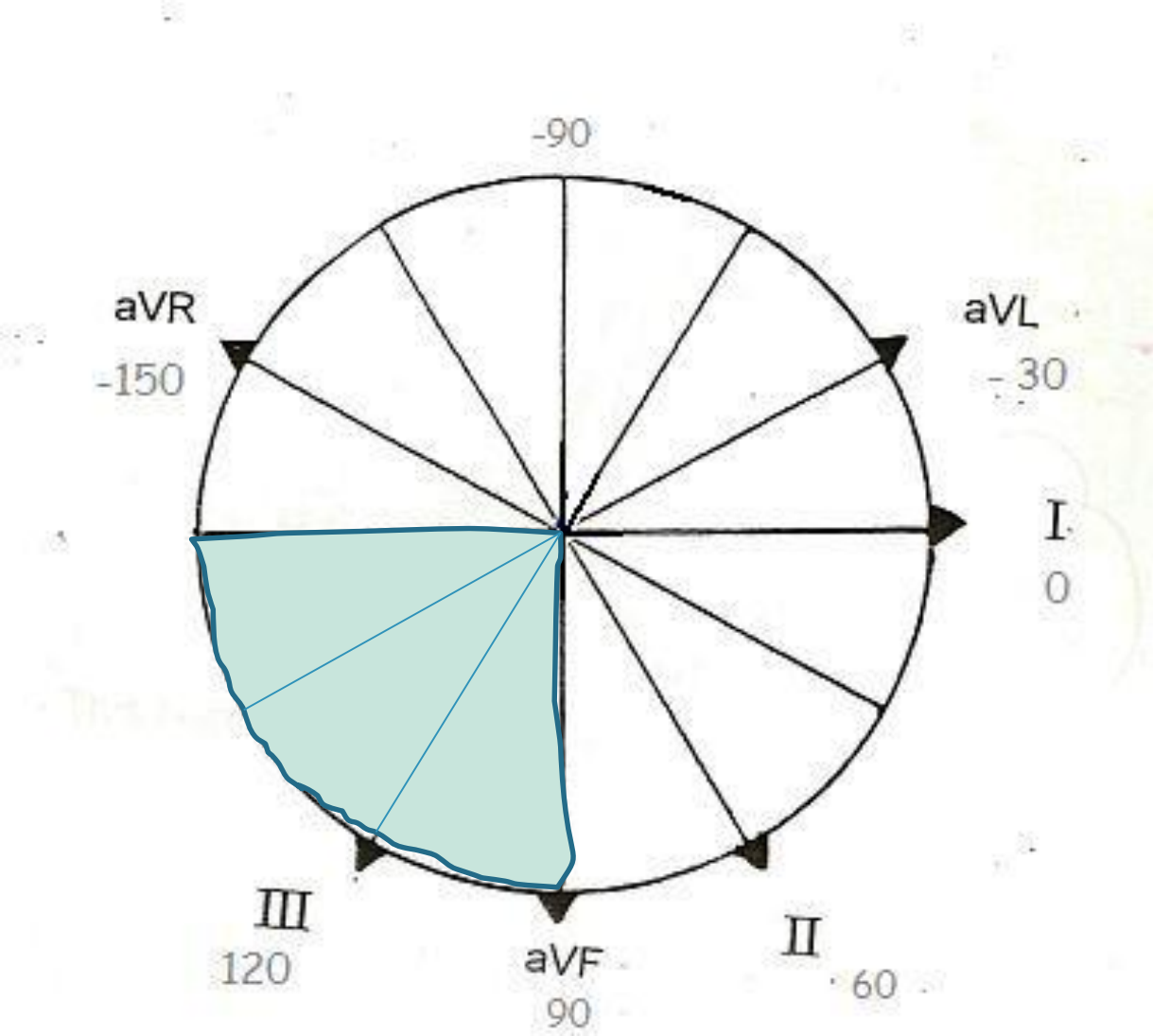
This is the part of the circle that is considered to be "Right Axis Deviation"

90 degrees to 180 degrees.

Remember, the RIGHT side of the heart is low – toward the right leg.

Question:

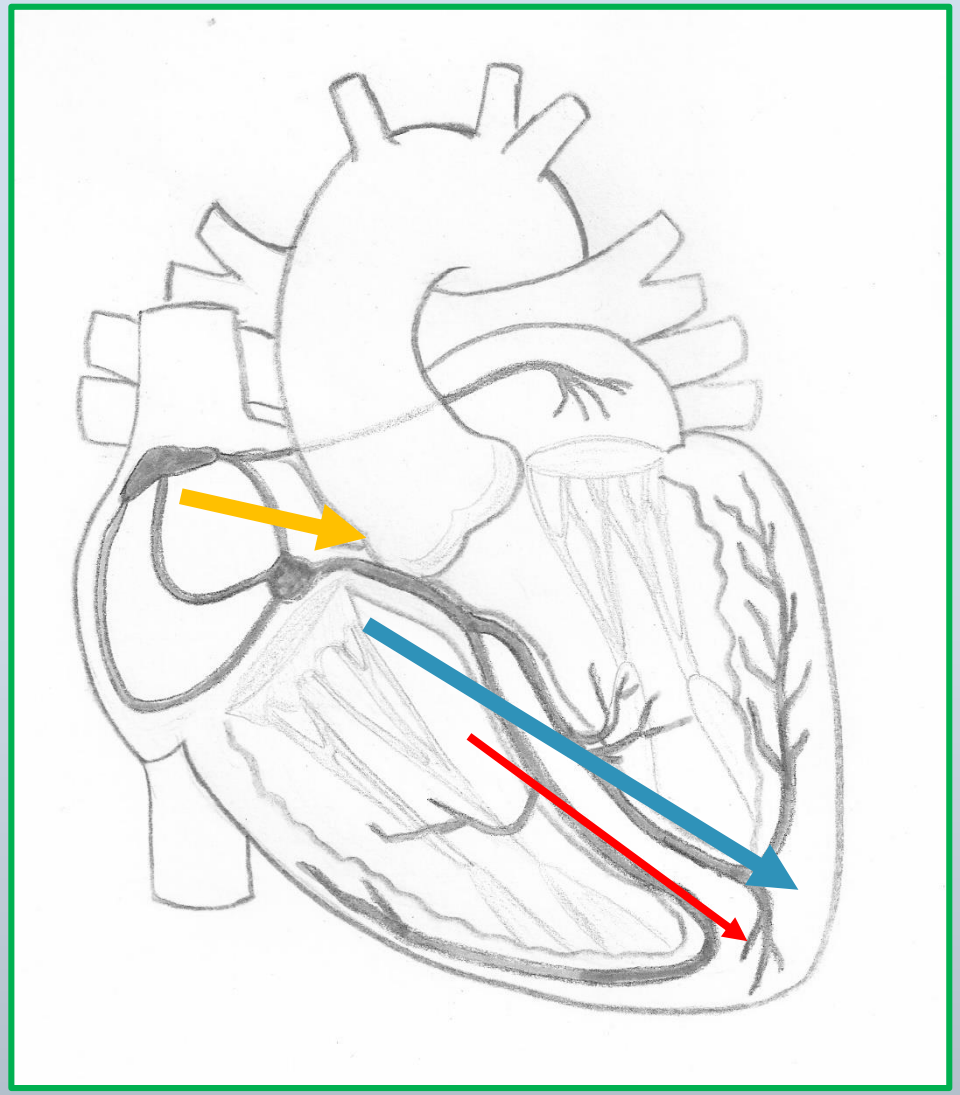
Which lead do you think will have the tallest upright QRS in RIGHT AXIS DEVIATION?



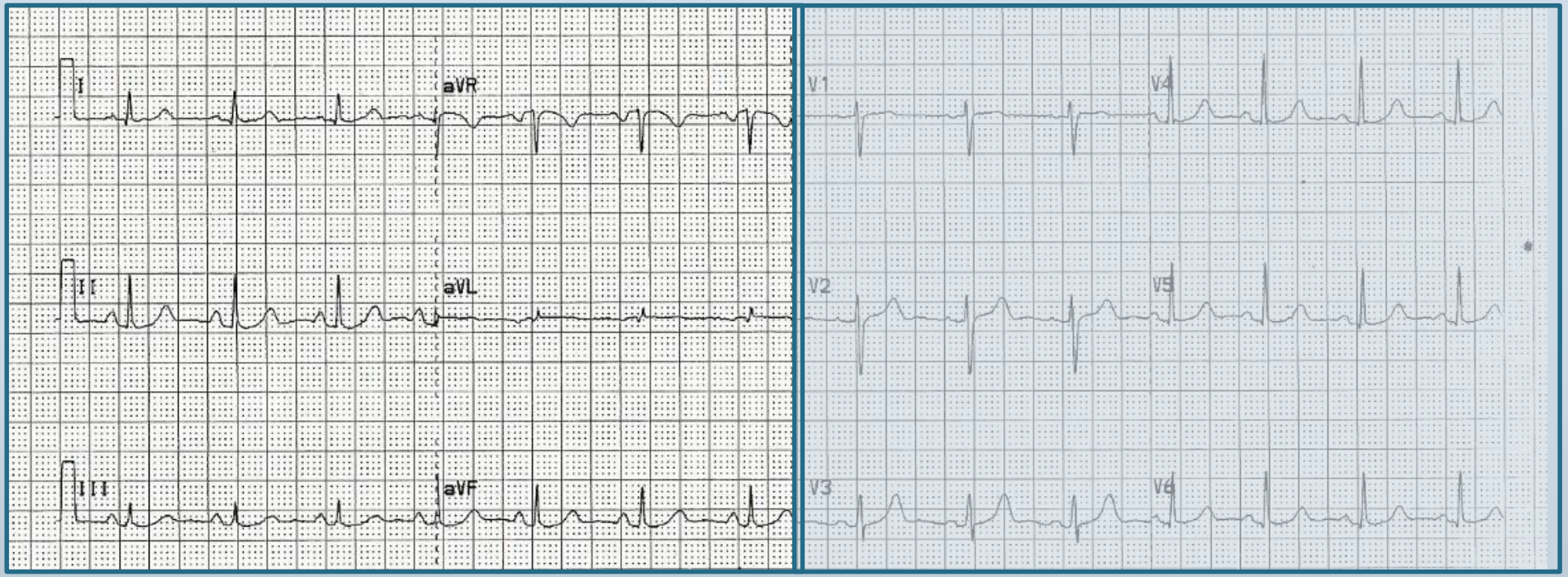
Using the ECG, we can easily determine the direction a depolarization wave is following through the heart.

The P wave has an axis, representing depolarization direction in the atria. The QRS axis represents depolarization direction in the ventricles. And the T wave axis represents repolarization direction in the ventricles.

Beginners should focus on the P and QRS axes.

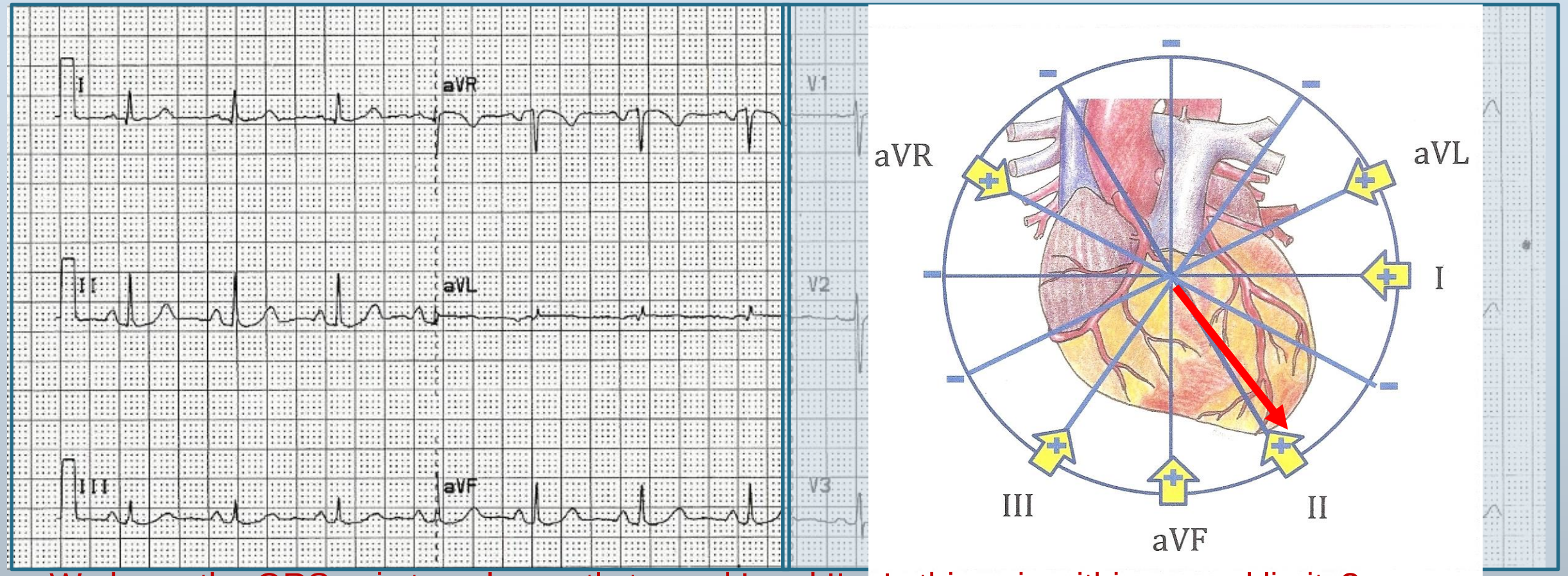


Look at the frontal plane leads in this ECG.



What is the TALLEST QRS complex in the Frontal Plane?

The tallest QRS is in Lead II

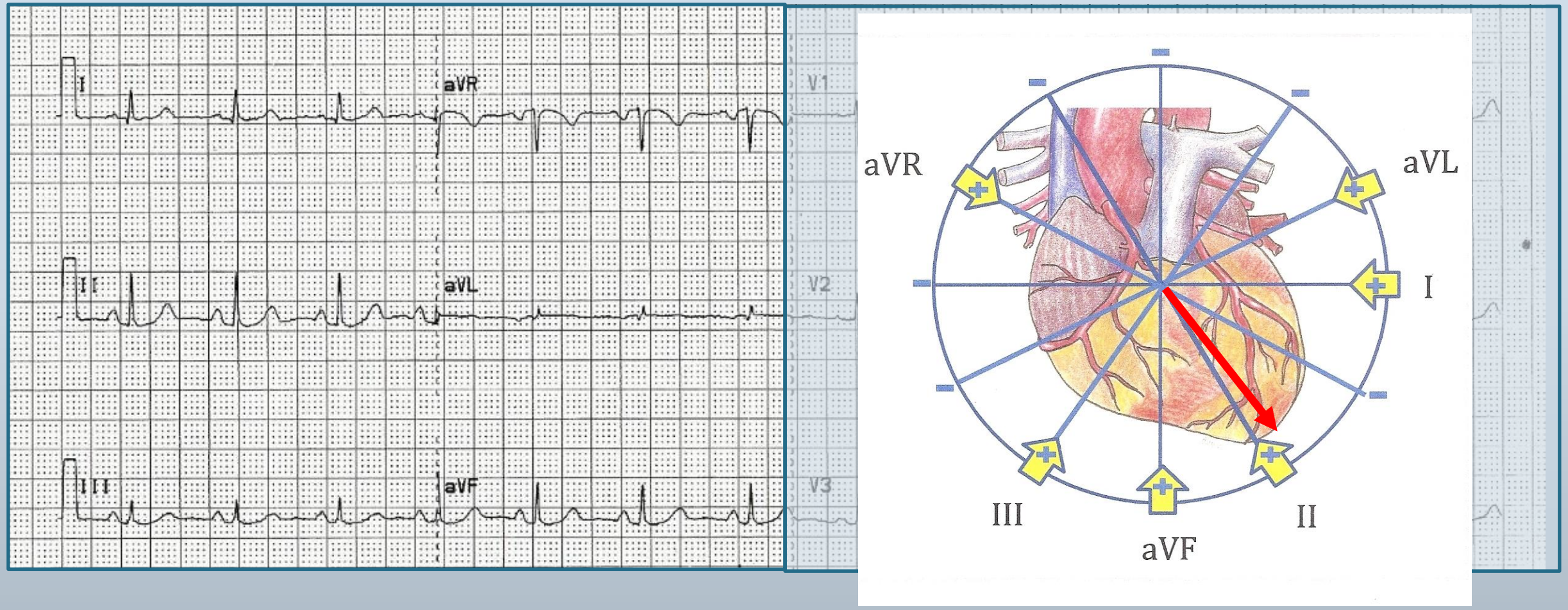


We know the QRS axis travels mostly toward Lead II.

Is this axis within normal limits?

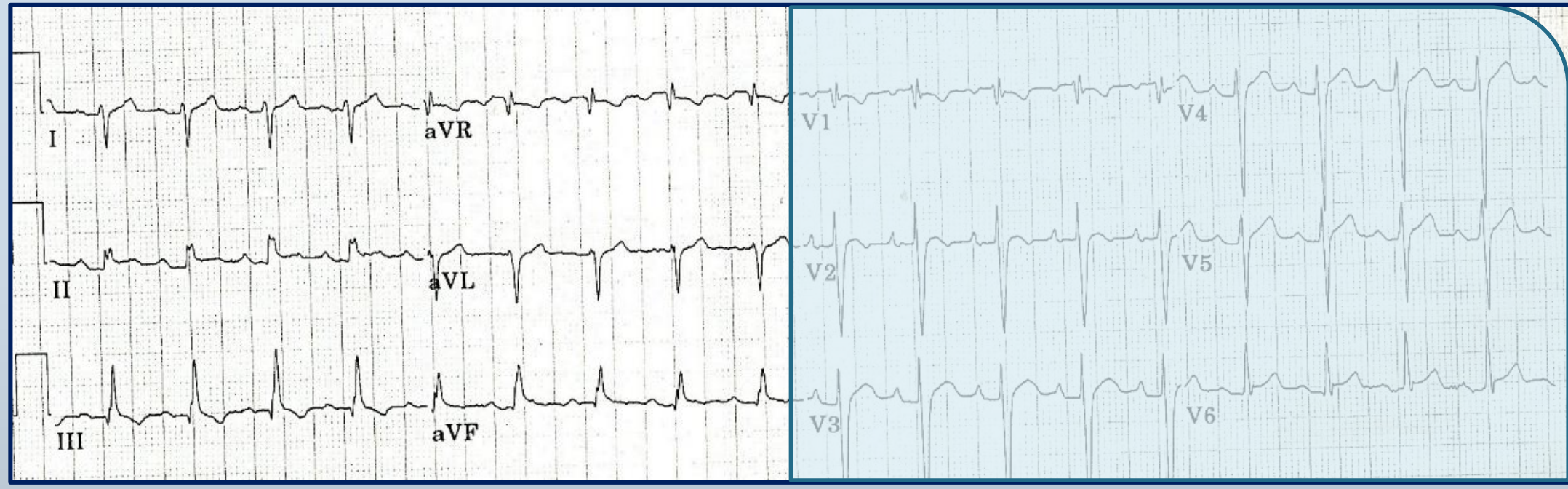
Why is aVR negative?

Why is aVL so small and biphasic?



aVR is oriented toward the NEGATIVE pole of Lead II – it is BEHIND the electrical flow.
aVL is PERPENDICULAR to the heart's axis, so it doesn't record NEGATIVE or POSITIVE well.

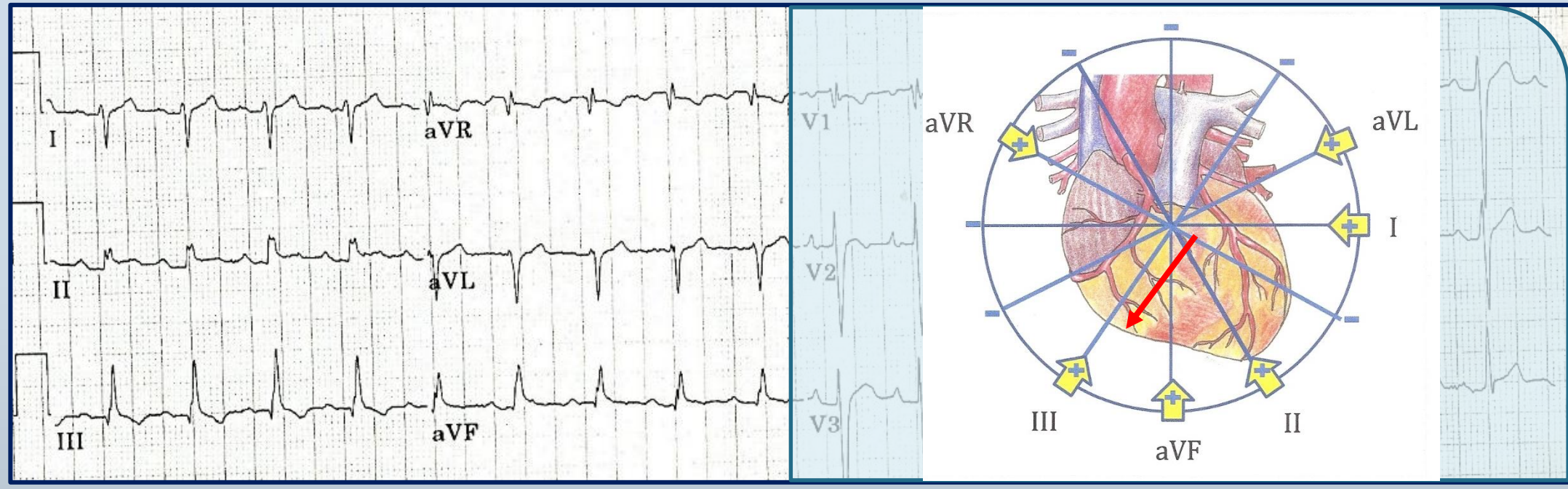
Which frontal plane lead has the tallest QRS?



In which direction does this person's axis travel?

Remember, Lead I is on the LEFT, Lead II is in the CENTER, and Lead III is on the RIGHT.

Lead III has the tallest upright QRS, and Lead aVL has the deepest negative QRS.

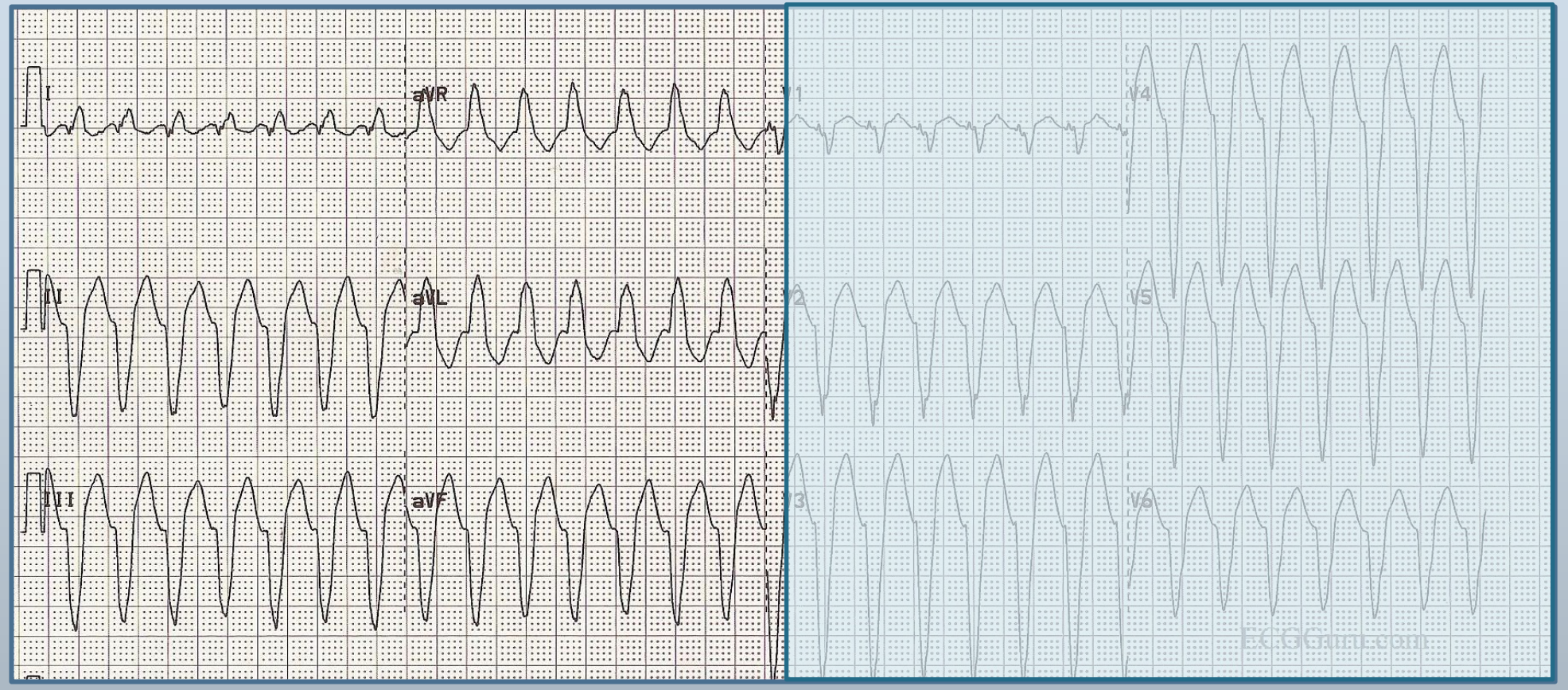


In RIGHT AXIS DEVIATION, Lead III is taller than Lead II and aVL is NEGATIVE.

Look at this ECG, the heart diagram, and the statement above, and make sure they make sense to you before you proceed. If they don't make sense, go back to the beginning and find out where you need to review.

Let’s try another one.

Which lead has the tallest QRS? Is there a nearly biphasic QRS?98



This axis travels BACKWARD!

This rhythm is ventricular tachycardia. The ectopic focus where it originated is LOW in the heart – the wave travels backward, which is called “RETROGRADE CONDUCTION”

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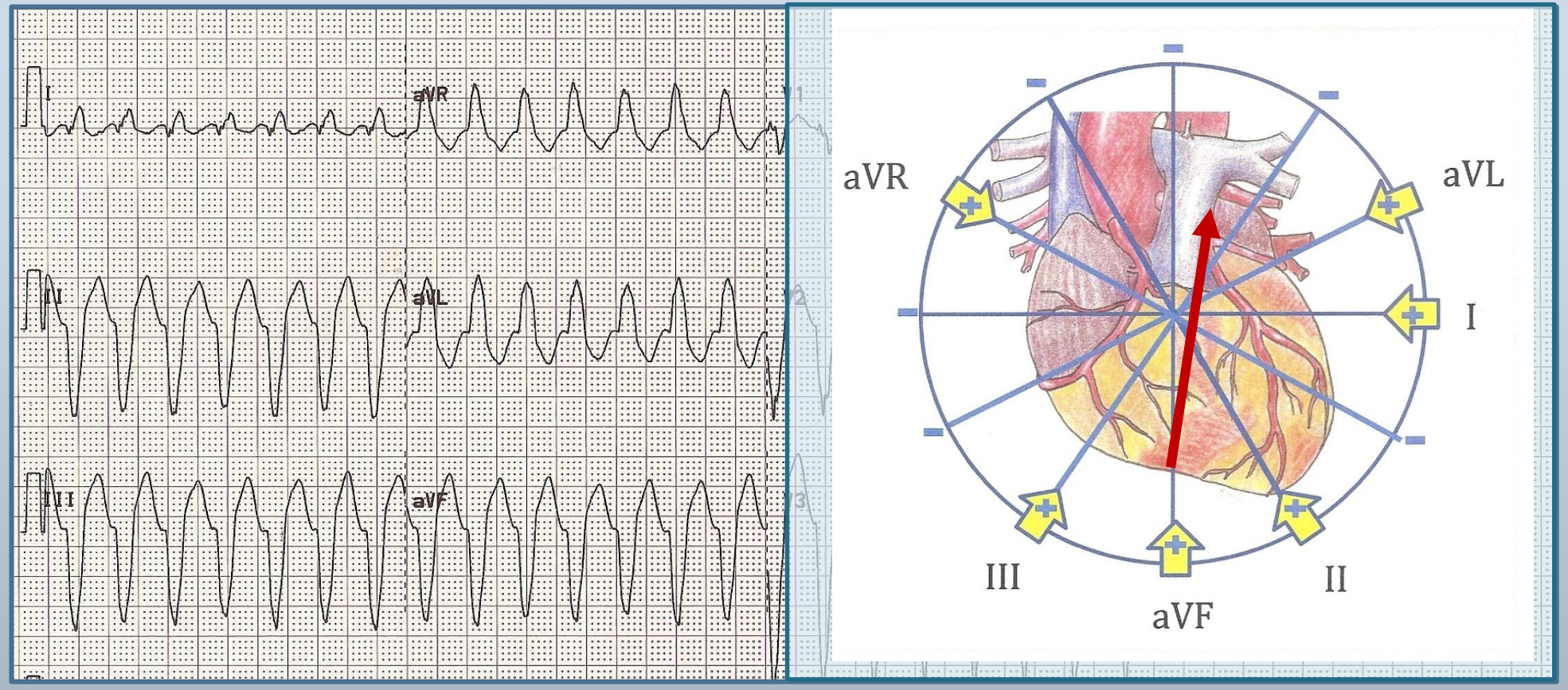

Why didn’t we point the arrow DIRECTLY toward Lead aVL, the tallest upright?

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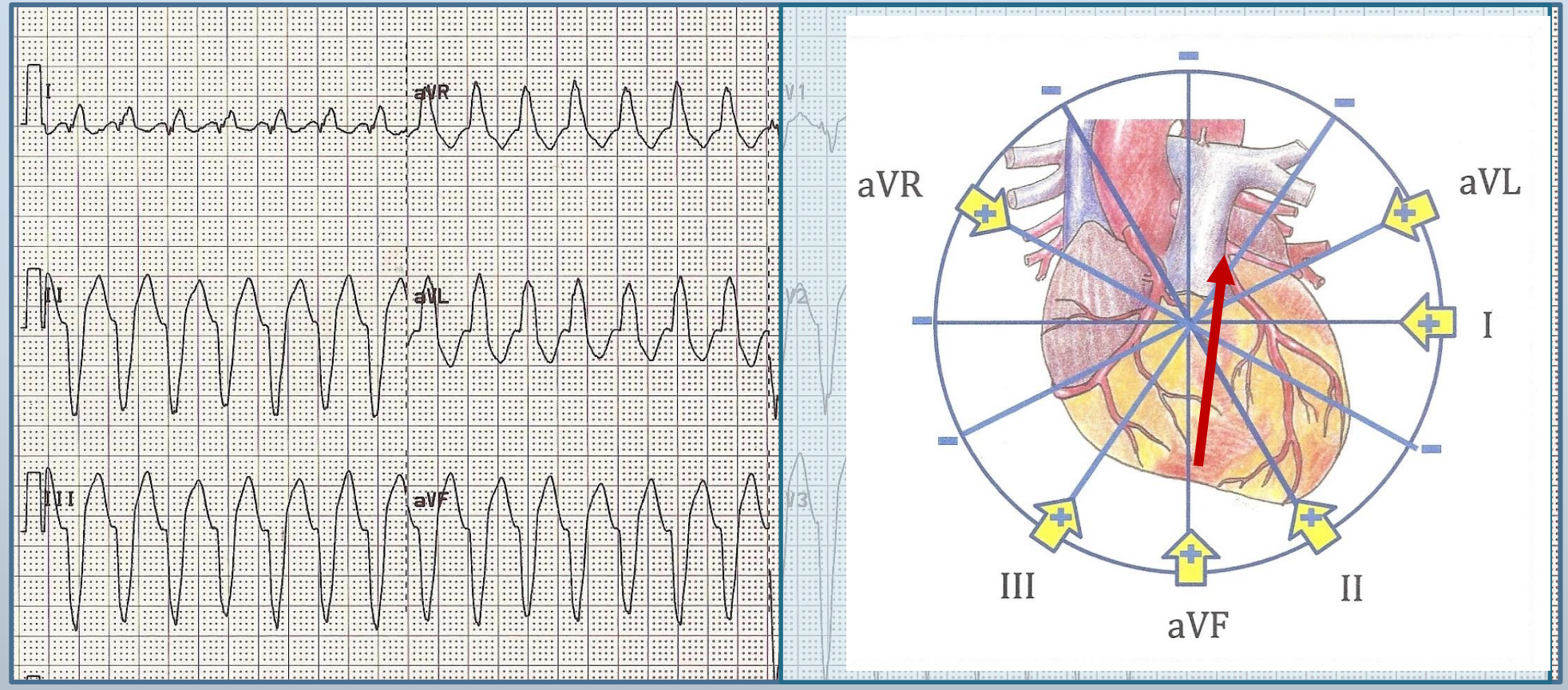
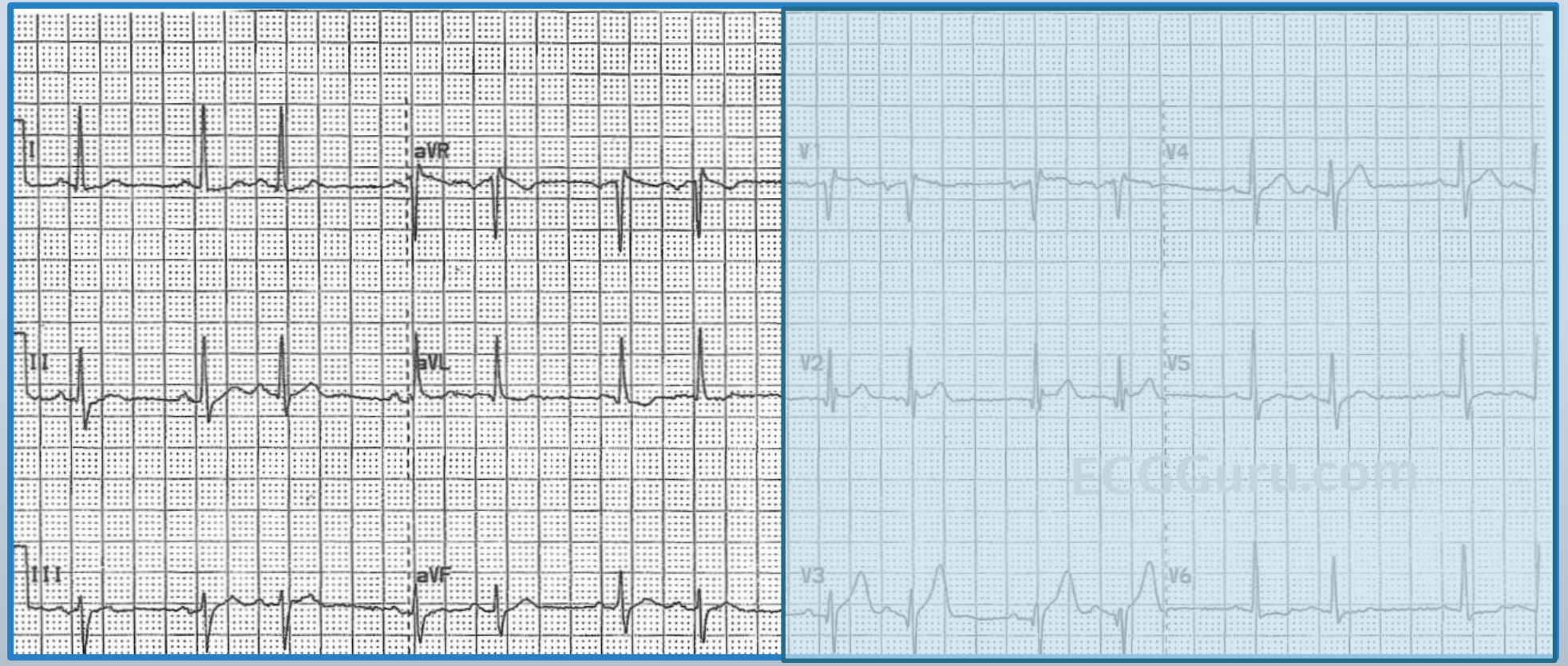


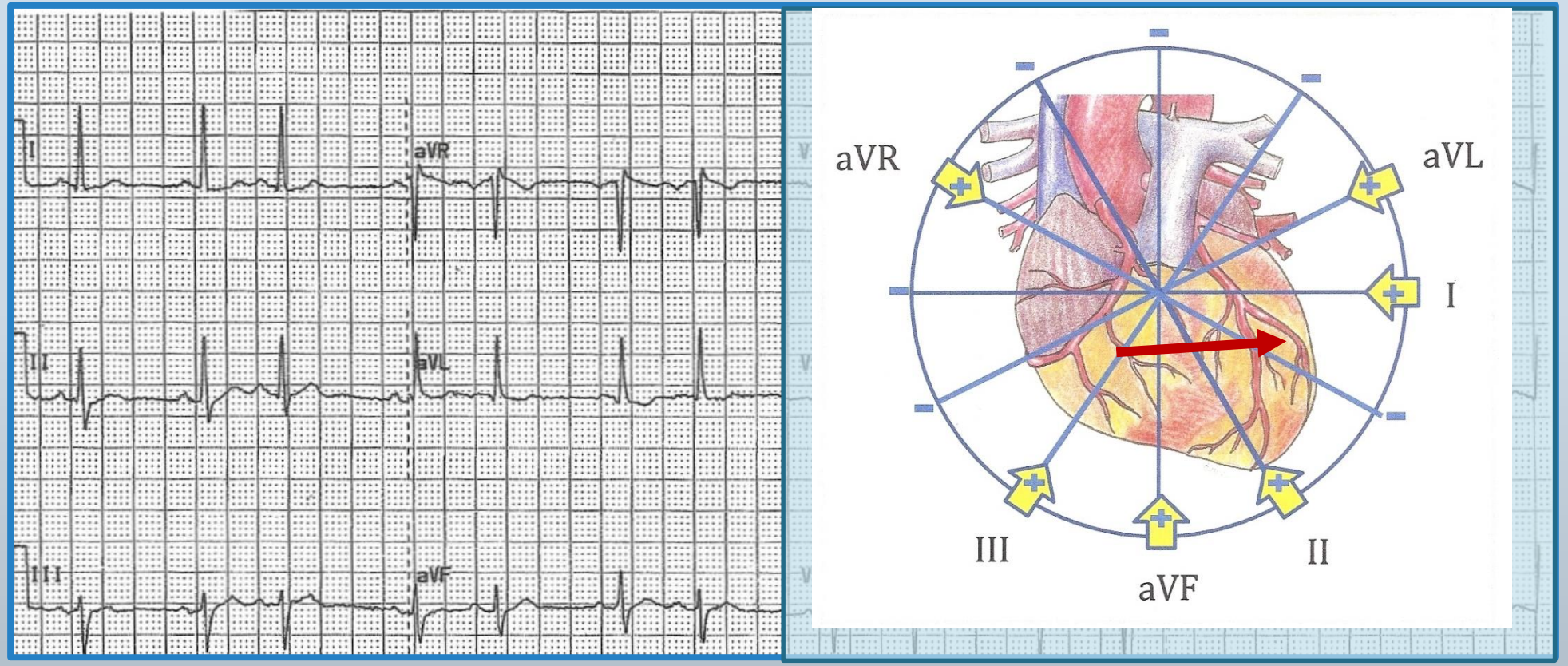
Because Lead I is small and biphasic, a sign that this heart’s axis is PERPENDICULAR TO LEAD I.
Look at aVF - it is deeply negative, just like we would expect it to be!

Here's one more practice ECG. Which is the tallest frontal plane QRS?



Is there an equiphasic QRS?

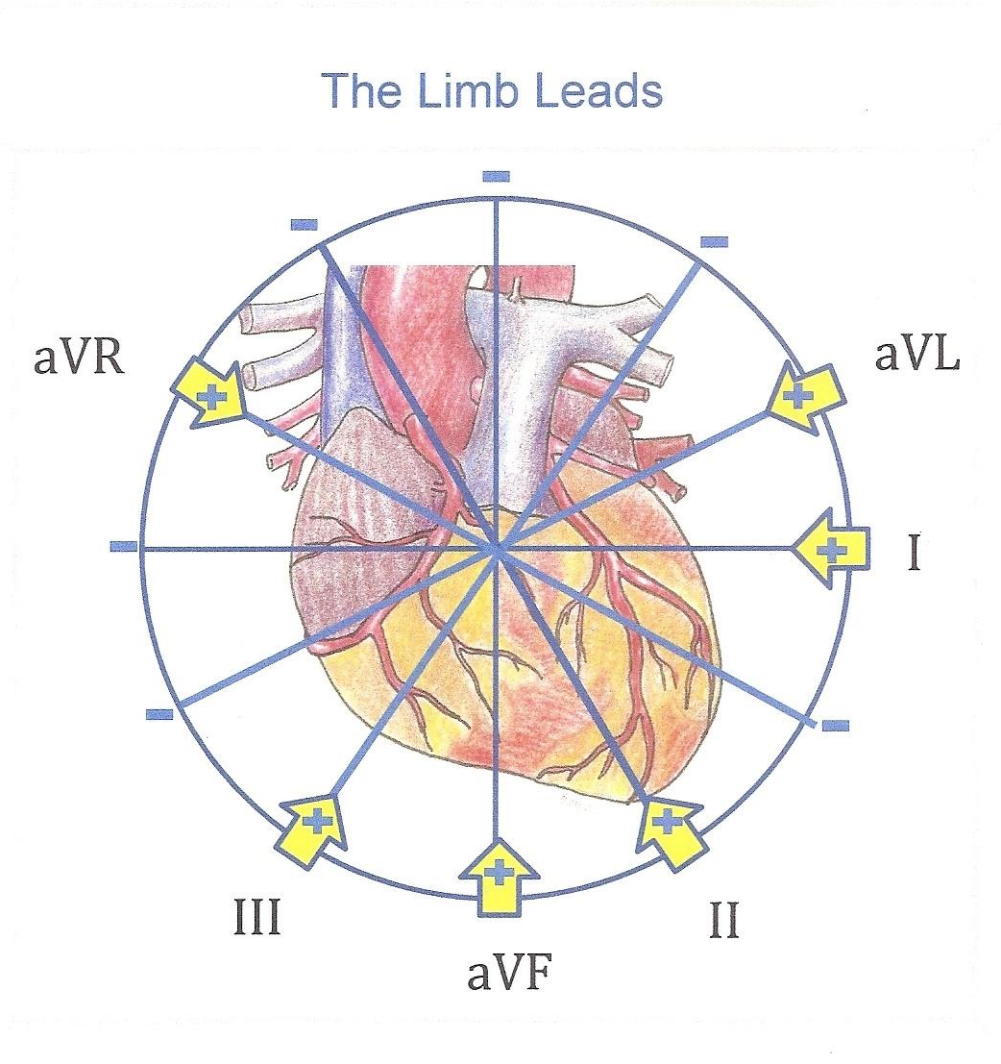
The tallest QRS is in Lead I.
aVF is equiphasic.



Does it make sense to you that I drew the arrow toward Lead I and perpendicular to aVF?

Advice For Understanding & Using Axis

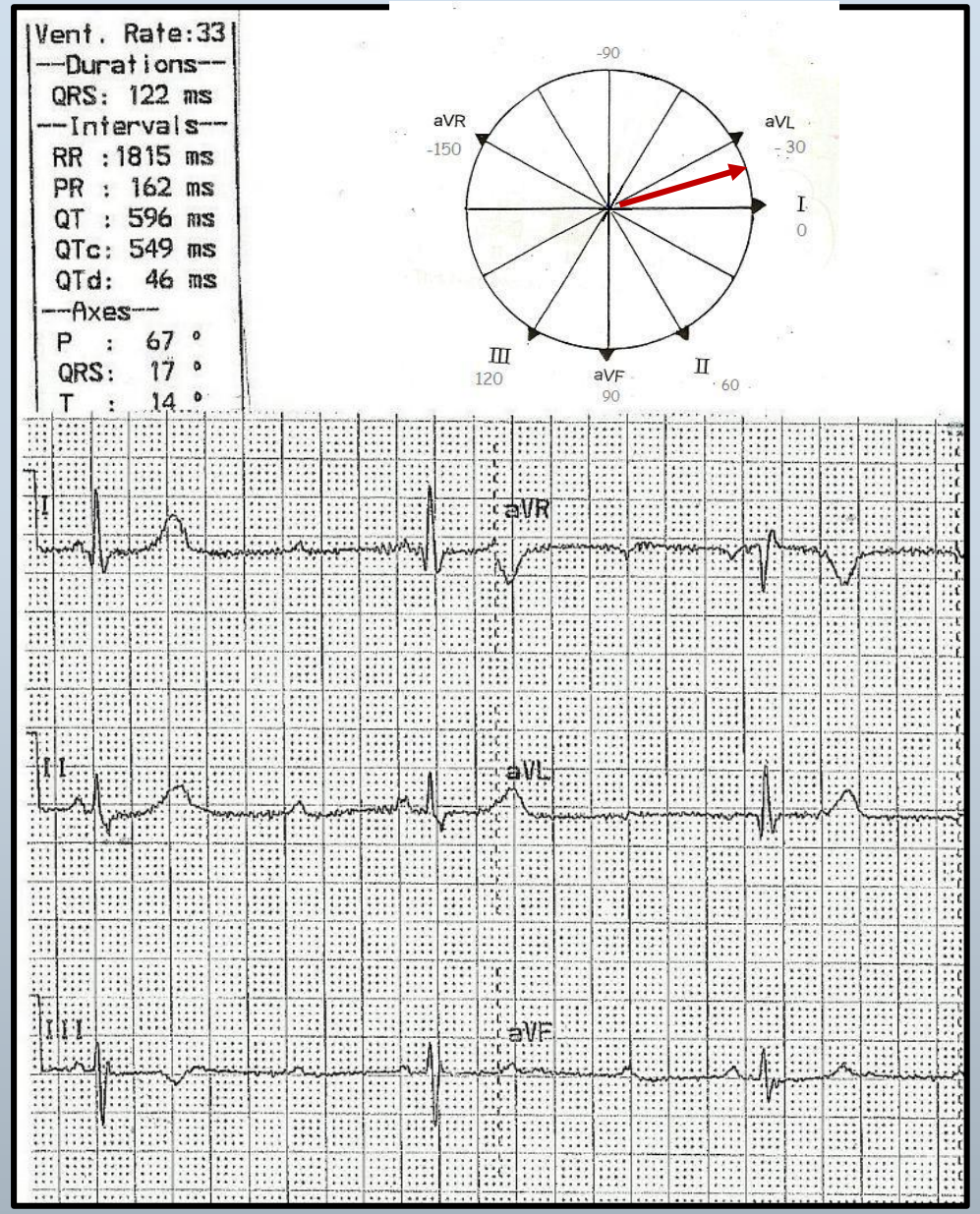
- Learn to see the frontal plane leads on the hexaxial reference circle, and memorize where the positive electrodes are for each lead.



Advice For Understanding & Using Axis

- Don’t worry about the “degrees” on the circle, just the general direction of electrical flow.

- Extra: The machine will give you the P, QRS, and T axes expressed as degrees. So, if you need to know the exact axis, that information is available.

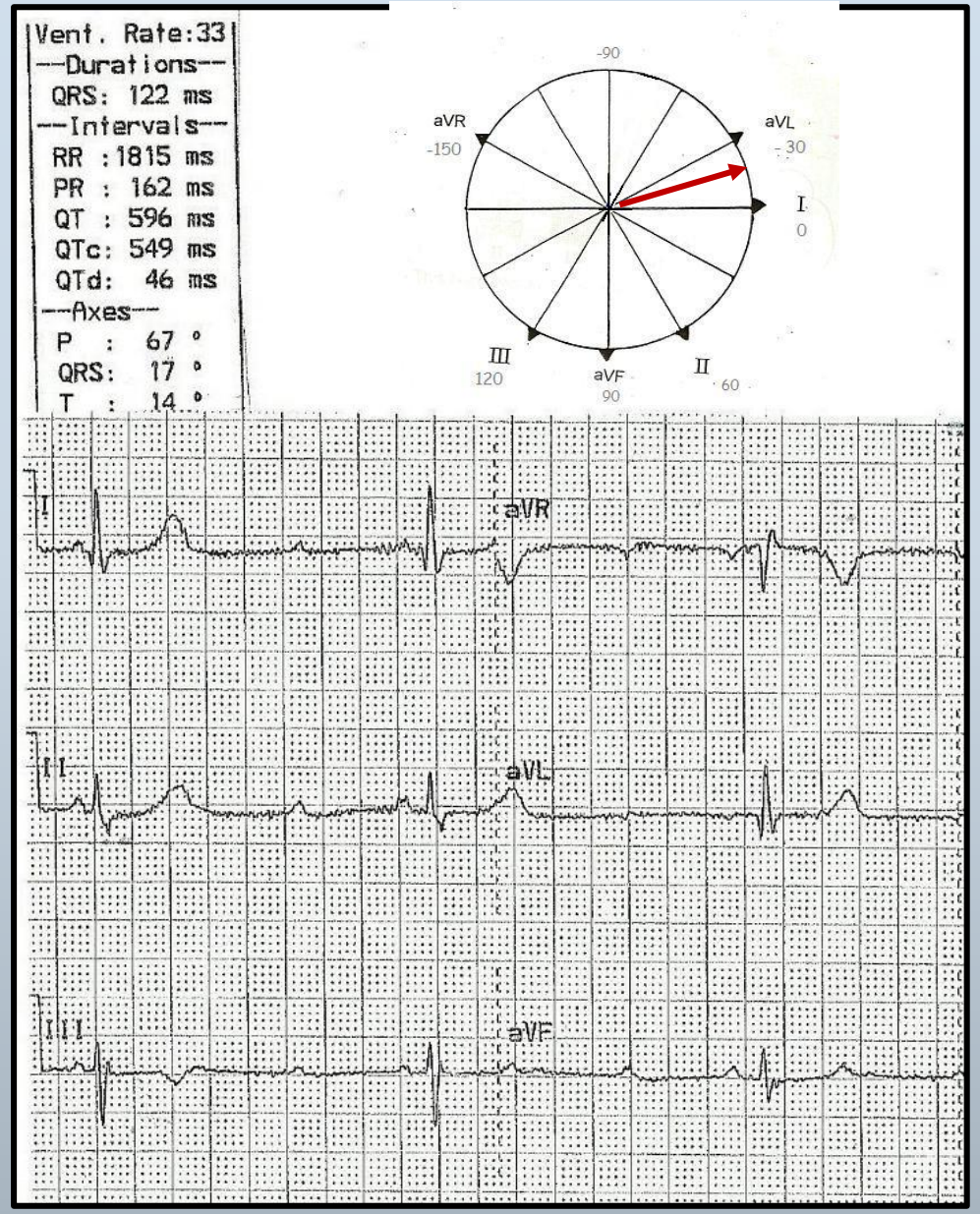


Advice For Understanding & Using Axis

- Practice calculating the QRS axis of every ECG you look at.

- Use the “Tallest R Wave” method.
- Use the “Deepest S Wave” method.
- Use the “Most Biphasic QRS” method.

- After you guess the axis based on one of the above, check the other frontal plane leads to see if they “agree” with your guess.



NOW, you know enough about axis to be ready to LEARN MORE!

- **There are great resources to help you determine axis with accuracy.**
- **Most ECG instructors have their favorite “tips” and “shortcuts” to get the most out of this skill.**
- **You will now better understand the explanations of experts when they interpret ECGs.**

Keep Practicing and Keep Reading!

Dawn Altman

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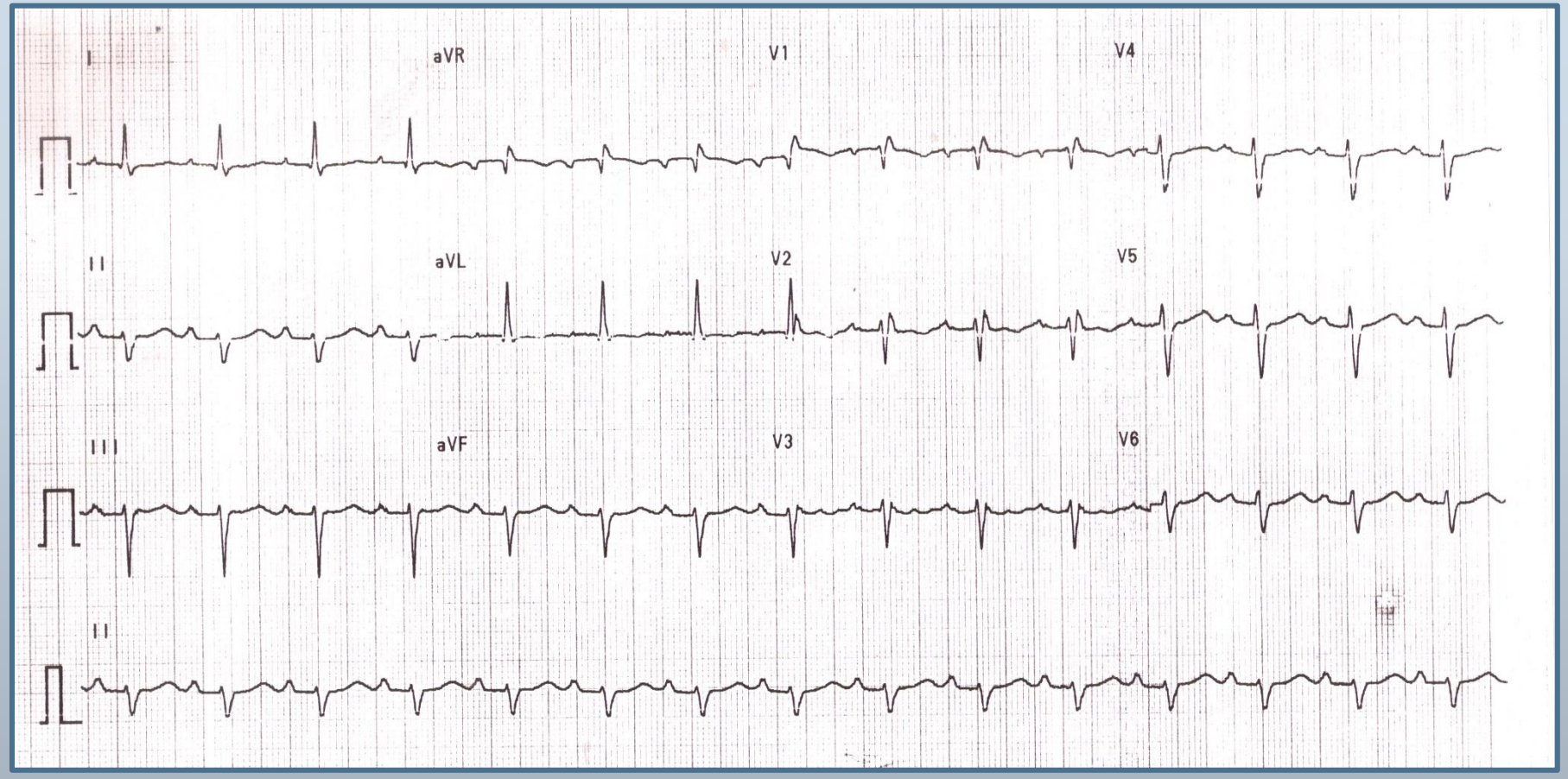
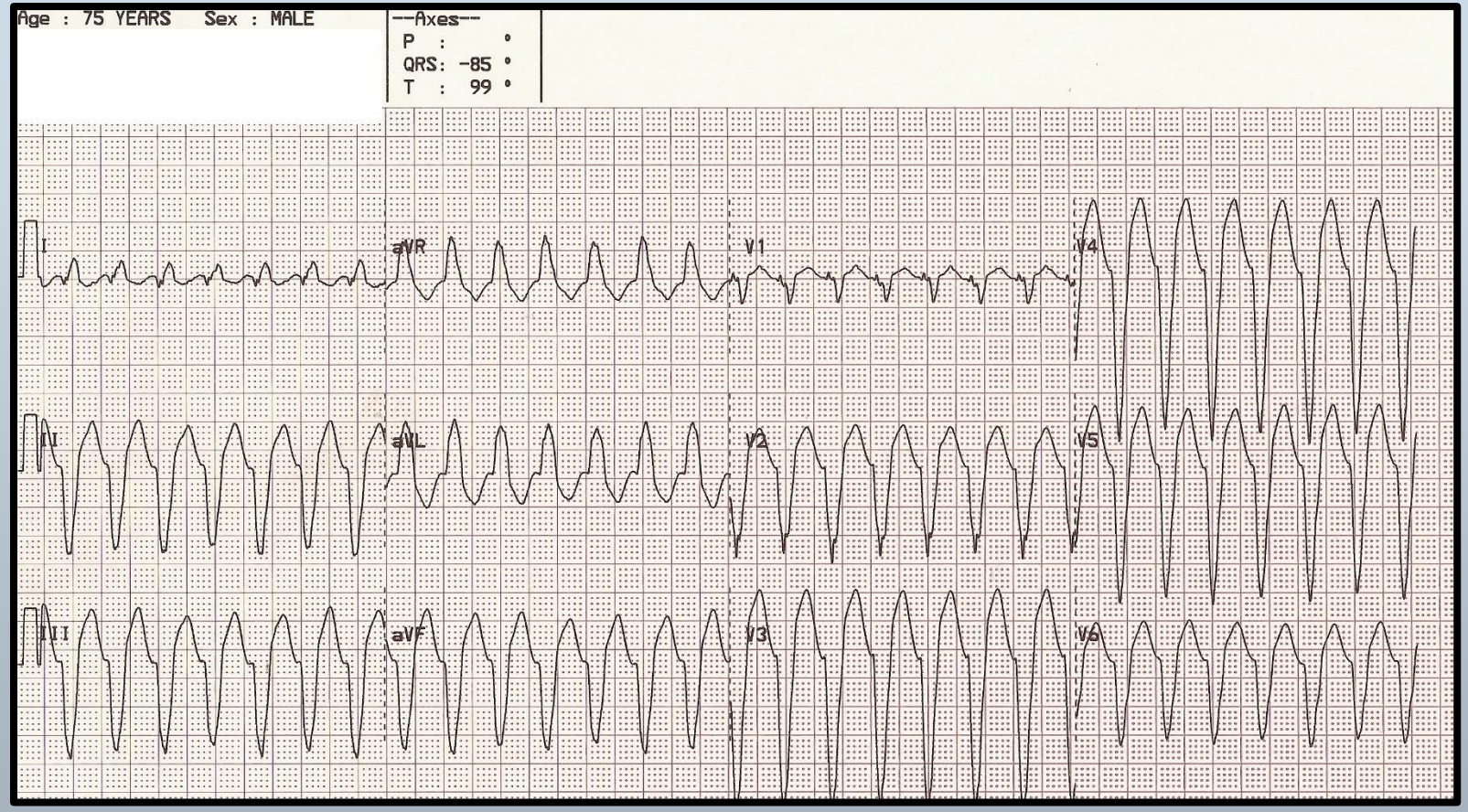
NOW, you know enough about axis to be ready to LEARN MORE!

- You will now be able to diagnose hemiblocks, which are blocks of part of the left bundle branch. The diagnosis is based on axis.



NOW, you know enough about axis to be ready to LEARN MORE!

- With this skill, you will be much more accurate when diagnosing wide-complex tachycardias.



NOW, you know enough about axis to be ready to LEARN MORE!

- You will readily recognize the abnormal P waves of retrograde conduction, such as that seen in JUNCTIONAL RHYTHM.