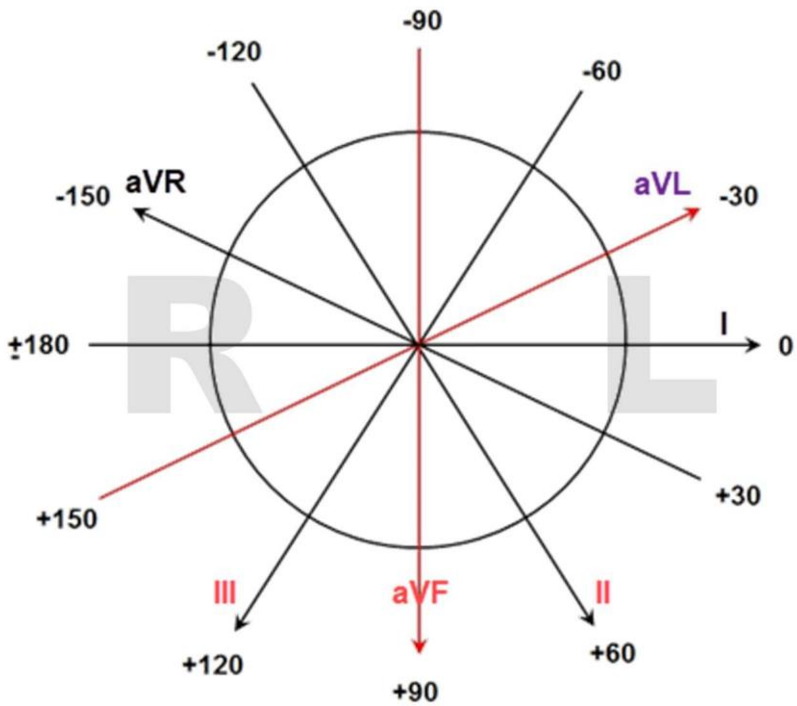
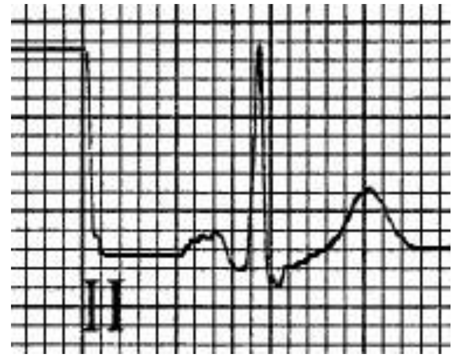
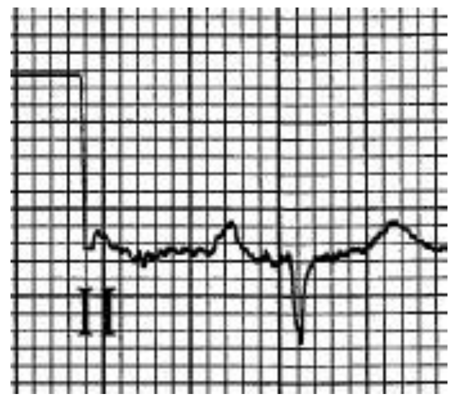
The Hexaxial Reference Grid (HRG): Part 2





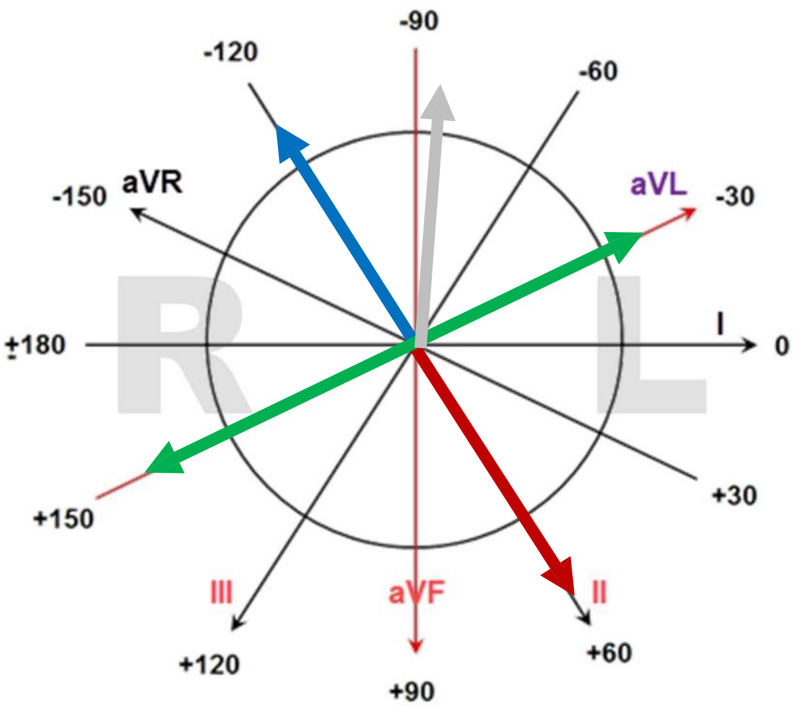


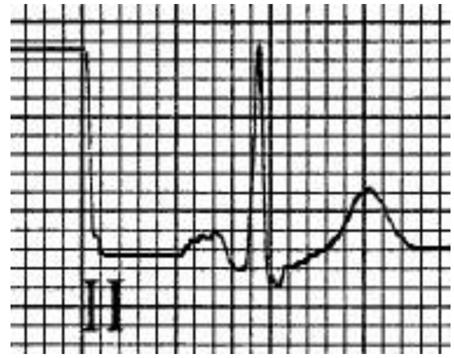
Here we have two Lead II snippets from different ECGs: one QRS is POSITIVE and the other is NEGATIVE. At what point does Lead II – or ANY lead, for that matter – turn from POSITIVE to NEGATIVE. To understand this, there are a couple of things about the HRG that you must know and engrain in your memory forever!

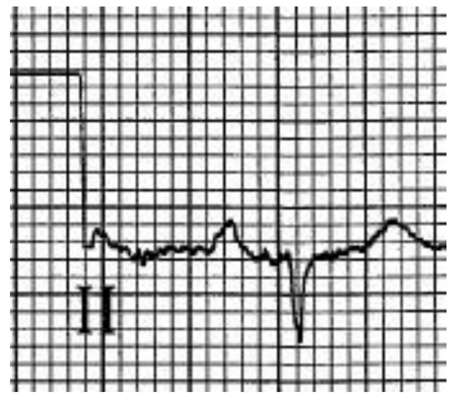
First, you MUST know the location of ALL the POSITIVE poles for all six limb leads! That's easy. You know that Lead I acts as the horizontal axis (0°) and Lead aVF acts as the vertical axis (+90°). Next, Leads aVR and aVL are just 30° above the Lead I axis. aVR is on the right ("**R**" for "right") at -150° and aVL is on the left ("**L**" for "left") at -30°. Only two more leads to go! Leads II and III are located on either side of Lead aVF (the vertical lead axis). Lead III is on the RIGHT and Lead II is on the LEFT. "Right" and "left" refer to the patient's "right" and "left." Assume the patient is facing you.

Lead aVF acts as the middle of the inferior leads with Lead III on the RIGHT and Lead II on the LEFT. I would like to point out that in addition to being INFERIOR leads, Lead III is also a RIGHT-sided lead and Lead II is also a LEFT-sided lead.

Now back to the snippets…



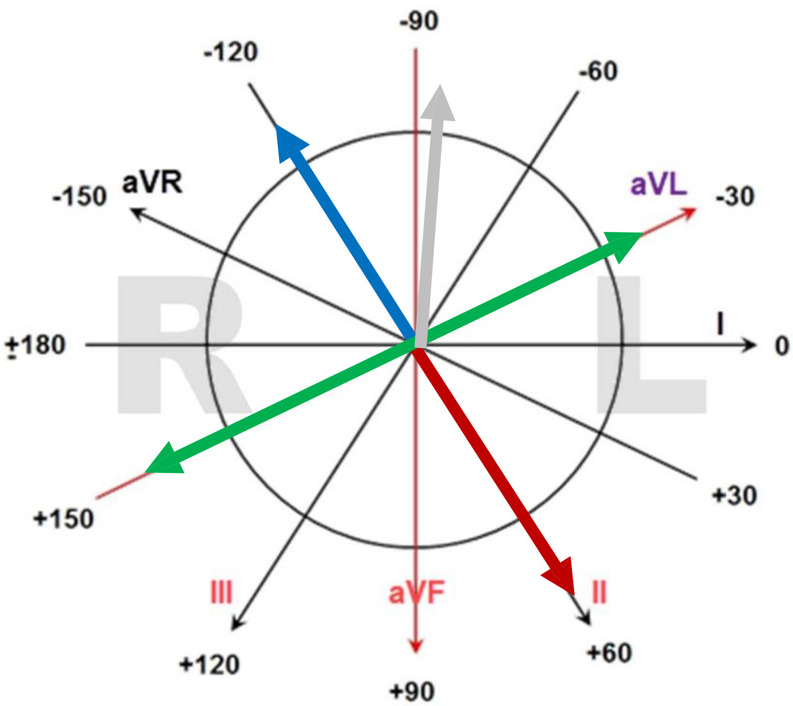


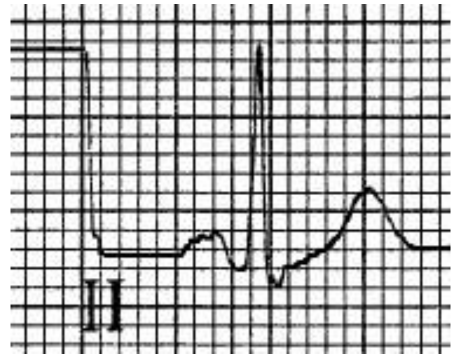


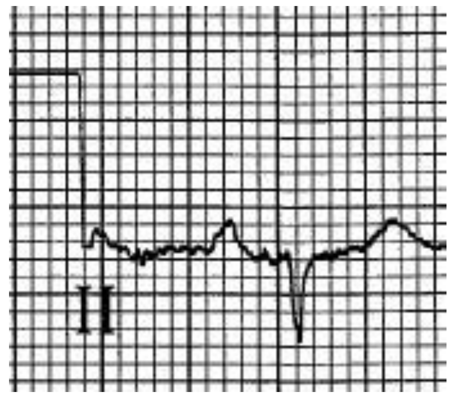
Look at the Lead II axis on the HRG. You can follow it from its POSITIVE pole at +60° to its NEGATIVE pole at -120°. Each lead axis – including Lead II – changes polarity where it intersects with the other lead axes. But – more specifically – it changes where it crosses the lead axis that happens to be ***perpendicular*** to it. In the case of Lead II, we can see that the lead axis perpendicular to Lead II is Lead aVL (green double-arrow). Please note that there are THREE perpendicular pairs and each pair includes one standard lead (I, II or III) and one augmented lead (aVR, aVL or aVF). Perpendicular pairs cannot be of the same type of lead, e.g., Lead I cannot be perpendicular to either Lead II or Lead III.

OK, it’s easy to see that Lead I and Lead aVF are perpendicular to each other. And you just learned that Lead II and Lead aVL are perpendicular to each other. That leaves Lead III and Lead aVR as the third pair of perpendicular leads. So, looking at the HRG above, we can see that any vector that points from -29° around the lower part of the HRG to +149° will be seen in Lead II as a POSITIVE or primarily POSITIVE complex.

So, the mean QRS vector as seen in the upper snippet is located somewhere in that range. As the vector becomes more and more parallel to the lead axis – and if it is pointing toward the POSITIVE pole of that lead axis (like the red arrow) – the QRS will become taller and more completely positive. That is the case in the upper snippet – the QRS is very tall and almost completely POSITIVE except for a very small s wave. The mean QRS vector is pointing very close to the Lead II axis.





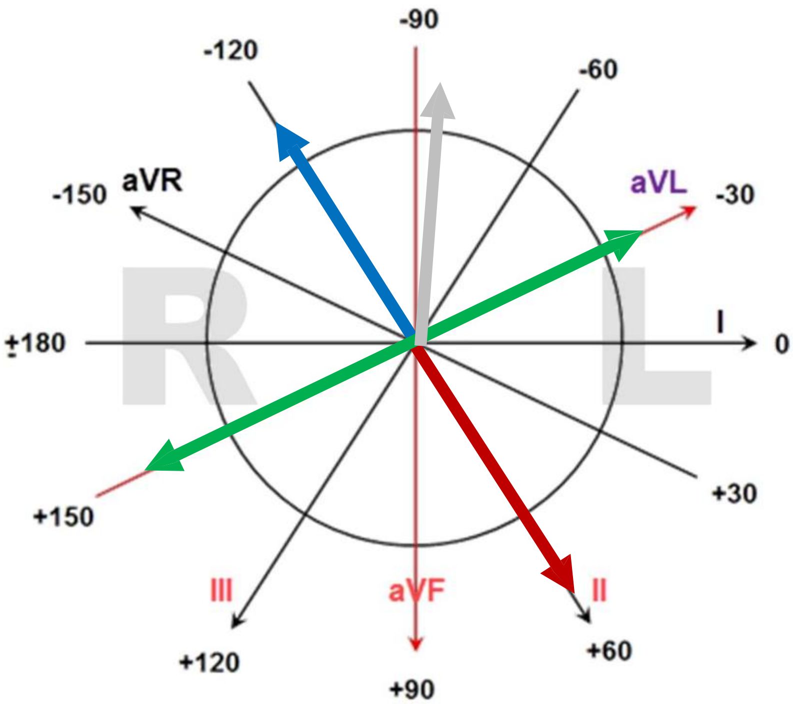


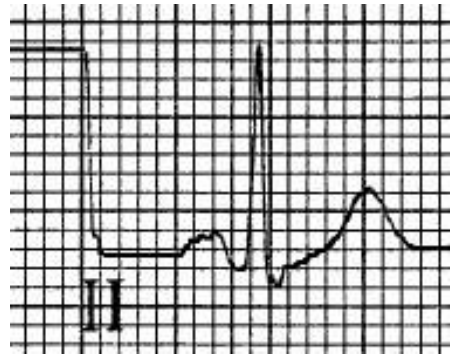
Now let's look at the lower snippet with a predominantly NEGATIVE QRS complex. We know immediately that the mean QRS vector – as seen by the Lead II POSITIVE electrode – must be on the other side of the Lead aVL axis (the axis perpendicular to Lead II – green double-arrow). Is the mean QRS vector represented by the blue arrow or the gray arrow? If it were pointed directly at the NEGATIVE pole of Lead II (blue arrow), it would be very deep and monophasic – all NEGATIVE. That's not quite the case here. The QRS is not what I would call very deep and there is a small r wave present initially. If the QRS vector were pointed directly at the NEGATIVE pole of Lead II, it would be completely monophasic. Therefore, the gray arrow more accurately represents the mean QRS vector.

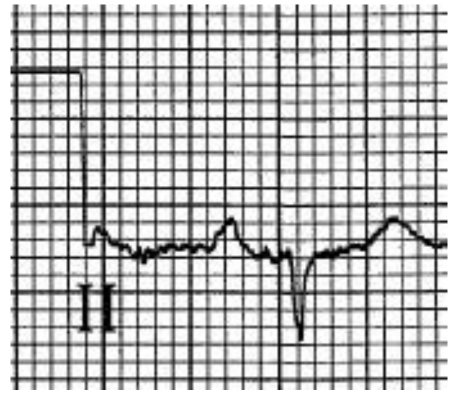
How would the mean QRS vector represented by the red arrow appear in Lead aVF? Well, any vectors below the Lead I axis (the perpendicular to Lead aVF) would result in QRS complexes that would appear POSITIVE or upright in Lead aVF.

How would the mean QRS vector represented by the red arrow appear in Lead I? Well, any vectors to the left of the Lead aVF axis (the perpendicular to Lead I) would result in QRS complexes that would appear POSITIVE or upright in Lead I.

How would the mean QRS vector represented by the red arrow appear in Lead aVL? This is a tricky question. You see that the vector (red arrow) is directly on the Lead II axis (we say that







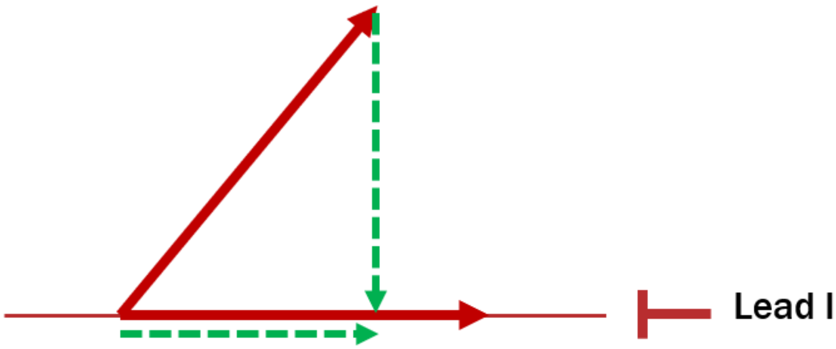
it is “parallel” to the Lead II axis). That means the mean QRS vector is exactly perpendicular to Lead aVL. Remember: Leads II and aVL are a “perpendicular pair.” When a vector is exactly perpendicular to a Lead axis, it will be invisible to that Lead (see illustrations on next page). On the ECG tracing, it may appear as isoelectric (flat baseline) or equiphasic (equal positive and negative deflections). In this case, you see a nearly isoelectric (flat) baseline replacing the QRS complex. Here is an example of that concept from a real 12-lead ECG...

Here, in Lead II, we have a tall, completely monophasic R wave representing the QRS. The mean QRS vector is pointing directly at the POSITIVE pole of Lead II located at +60°. In Lead aVL – the “other half” of the perpendicular pair – we see what is essentially a flat, isoelectric baseline. Does the flat baseline in Lead aVL represent a problem – some pathology, perhaps? No! This is just an effect caused by the mean QRS vector and its appearance in Lead II and the perpendicular lead to Lead II, which is Lead aVL. The QRS vector for this real ECG would be perfectly represented by the red arrow in the illustration above.

Any vector traveling PARALLEL to a lead inscribes the maximal deflection in that lead.

What happens when the impulse (vector) is traveling at an angle to a lead?

The angled vector leaves less “shadow” on the lead axis and a smaller deflection.

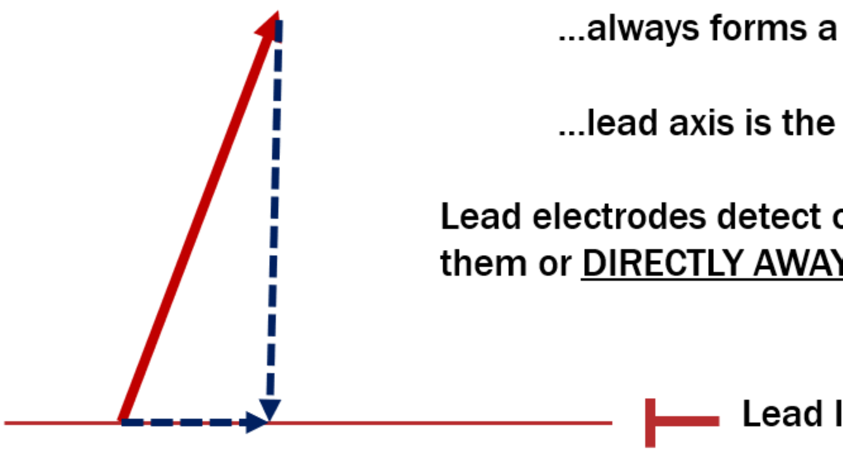


An angled vector...

...always forms a right triangle with the lead axis

...lead axis is the BASE of the right triangle

Lead electrodes detect only movement <u>DIRECTLY TOWARD</u> them or <u>DIRECTLY AWAY</u> from them

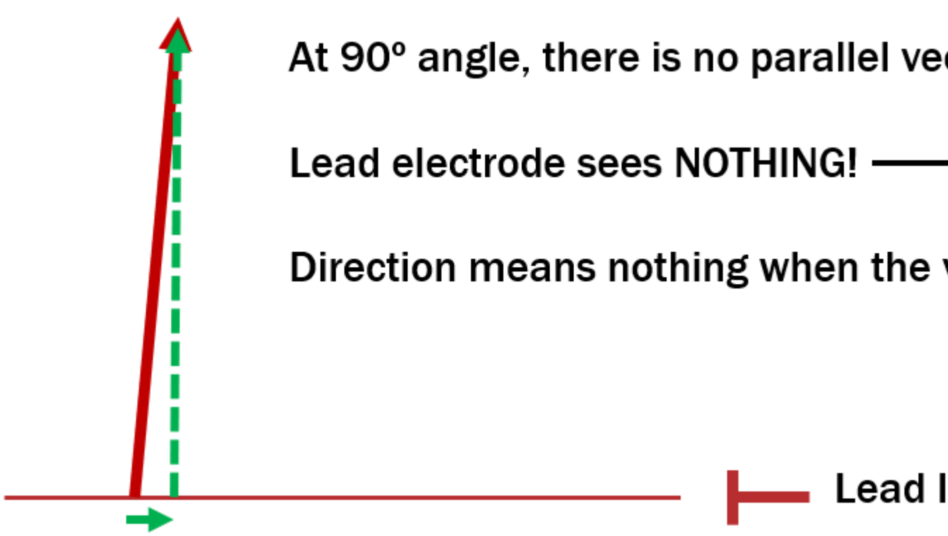


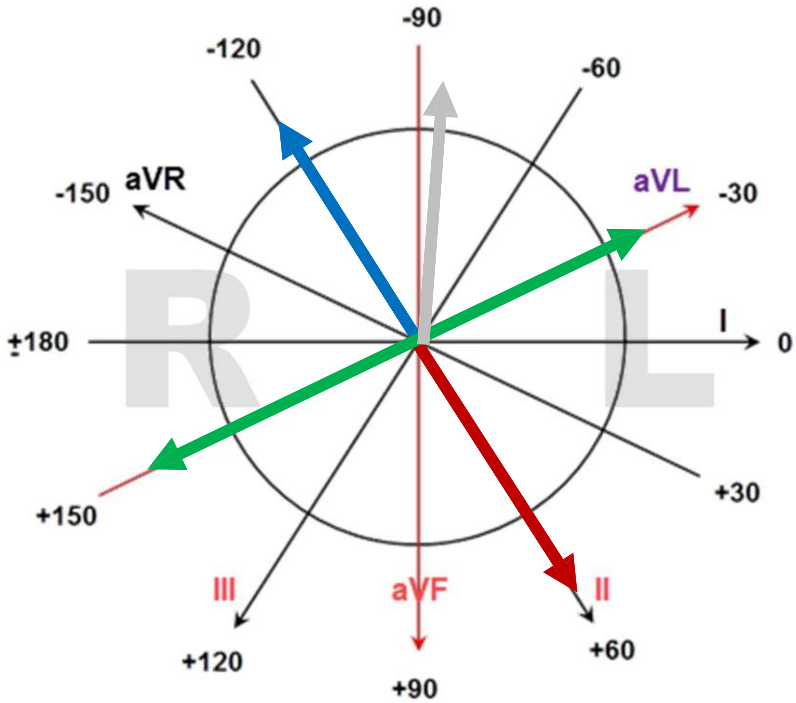
As the vector becomes vertical, less is directed toward the lead electrode.

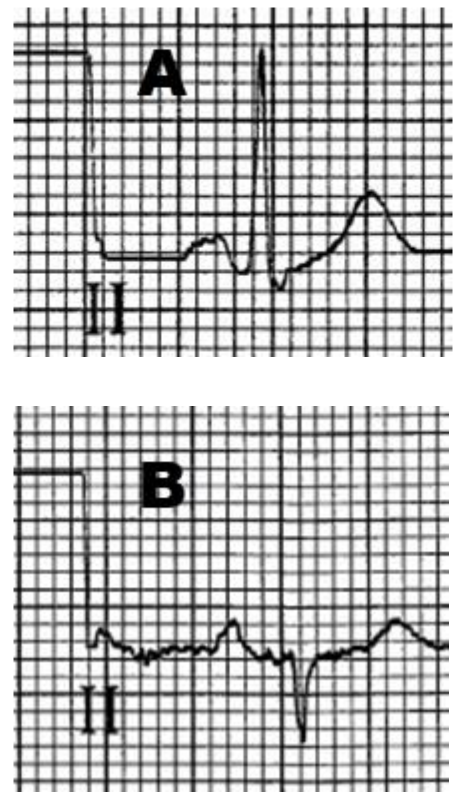
At 90° angle, there is no parallel vector

Lead electrode sees NOTHING! ⟶ ISOELECTRIC LINE

Direction means nothing when the vector is perpendicular







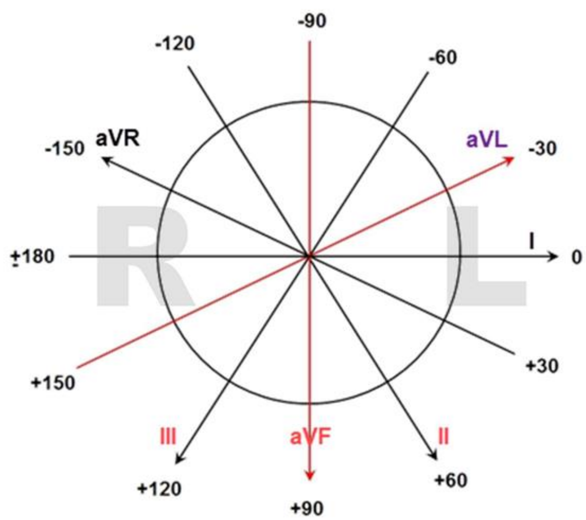
Familiarity with the Hexaxial Reference Grid, and how the mean QRS vectors are represented on it, can avoid unnecessary consults and workups.

Any vector that is pointing toward the side of the hexaxial grid that contains the POSITIVE POLE of Lead II will inscribe a POSITIVE DEFLECTION in Lead II. How do we define the POSITIVE side of Lead II as opposed to the NEGATIVE side? We use the lead that is perpendicular to Lead II – in this case, Lead aVL. So the axis (green arrow) of Lead aVL separates the positive deflections in Lead II from the negative deflections. All vectors – by convention – are drawn from the center of the HRG (where all the axes cross) toward the positive or negative pole of the lead in question.

So, a vector pointing toward +30° will appear as a net positive deflection in Lead II. “Net positive” means that the total QRS will be positive even if there is a Q wave or an S wave present; the R wave will be large enough to offset and compensate for the two negative deflections. The same concept applies to vectors that may be pointing to +120°, +90° or 0°. All are within the positive field of Lead II.

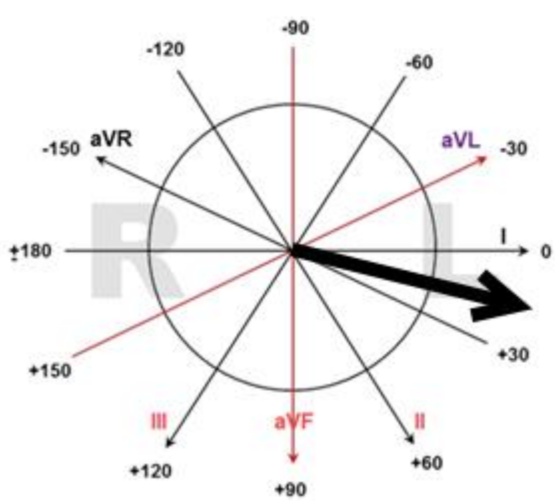
Now, what if a vector is pointing toward +150° or -30°? The deflection will be either isoelectic (or equiphasic). The idea of “+” or “−” has no meaning when the deflection is isoelectric.

OK… what if the vector is pointing toward -90°? It would be pointing toward the NEGATIVE side of Lead II and a predominantly NEGATIVE QRS would be inscribed in Lead II. It might be a monophasic QS wave or there may be a small r wave, but the net voltage value of the QRS would be negative.



Now let's try it for Lead III. What's the first thing you do? You locate the lead that is perpendicular to Lead III. You can quickly see that it is Lead aVR (you should know these perpendicular pairs by heart, so I will show you a quick and easy method later). Next, you locate the POSITIVE pole of Lead III which is at +120°. All vectors pointing toward the same side as the POSITIVE pole of Lead III will be inscribed as a positive QRS in Lead III. All vectors pointing to the other side will inscribe negative QRS complexes in Lead III. All vectors pointing to +60°, +90°, +120°, +150° and +180° (and all points in between) will produce positive, upright QRS complexes in Lead III. Vectors pointing to the other side of the Lead aVR axis will inscribe neagtive QRS complexes in Lead III.

There is only one mean QRS axis (ÂQRS) per ECG. If you know the axis, you can determine what all the QRS complexes should look like in any of the *frontal plane leads*.



Let's give it a try…

Here is an HRG with an arrow representing the mean QRS axis for an ECG. The axis appears to be about +15°. What should the QRS look like in Lead aVL? First, we locate the positive pole of Lead aVL and we find it at -30°. Next we must locate the Lead that is perpendicular to Lead aVL. That will be Lead II. OK… we are going to use the axis of Lead II that runs from +60° to -120° as the ***dividing line between the positive and negative QRS complexes*** in Lead aVL. Now where is the arrow pointing? It's pointing on the same side of the Lead II axis as the POSITIVE pole of Lead aVL. That means the QRS in Lead aVL will be POSITIVE, or UPRIGHT.

Let's do one more…

What should the QRS look like in Lead aVR? We see that the POSITIVE pole of Lead aVR is located at -150°. Next, the perpendicular to Lead aVR is Lead III. Now, for our purposes, Lead III has divided the HRG into a POSITIVE half and a NEGATIVE half. The POSITIVE half is on the same side as the POSITIVE pole for Lead aVR. Now where is the arrow (mean QRS axis) pointing? It is pointing toward the NEGATIVE side of Lead III, so the QRS in Lead aVR will be negative.

PEARL

Most mean QRS axes in the frontal plane tend to cluster around +60° which is the same as the lead axis for Lead II. When the axis points toward a particular lead, the QRS in that lead will be very tall. Unfortunately, the QRS in the lead that is perpendicular to it will be very small. Sometimes very, very small. The lead that is perpendicular to Lead II is Lead aVL.

Always be very mindful of Lead aVL. Because it is often so small due to its perpendicular orientation to Lead II, significant ST deviations – especially ST elevations – can be easily missed. If you are going to overlook and misdiagnose an acute MI, it will probably involve Lead aVL!

Here's that easy method of remembering the "Perpendicular Pairs:"

The trick here depends on the configuration of the limb leads on the printed ECG and it looks like a game of "Tic-Tac-Toe":