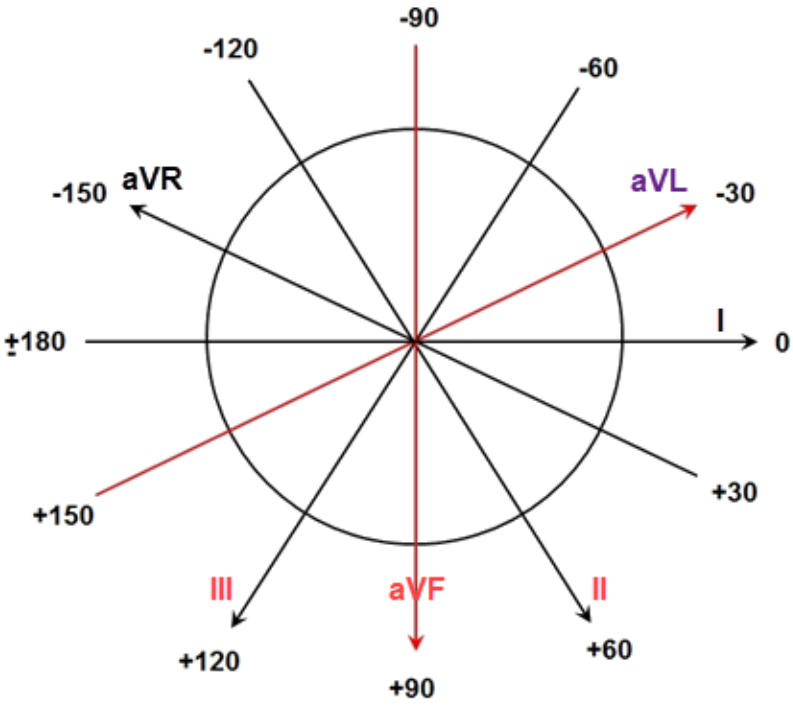
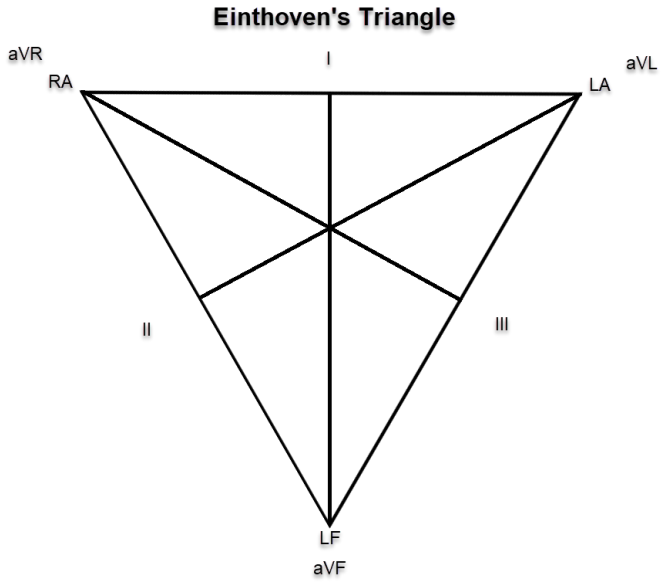
# The Hexaxial Reference Grid (HRG): Part 1



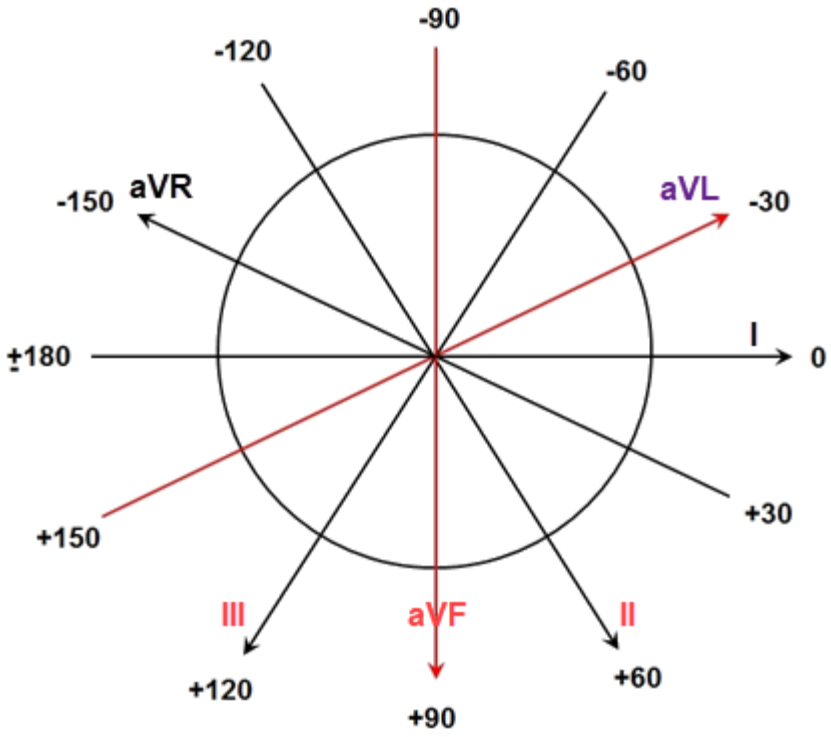

The **Hexaxial Reference Grid** (**HRG**) is an essential tool for anyone wanting to interpret 12-lead ECGs at an intermediate-to-advanced level. I've always compared it to the multiplication tables for a mathematician or the alphabet for a writer. But many people who must read ECGs every day have no idea what the Hexaxial Reference Grid (HRG) is or how useful it can be. I use it with every 12-lead ECG that I interpret.

This is the first in a weekly series of articles on the HRG that I will be posting on LinkedIn.




There are six axes that comprise the HRG and they represent the three *standard* leads and the three *augmented* leads. In the illustration on the left, if you can imagine moving the three standard leads (I, II and III) so that their centers also intersect at the point that the three augmented leads intersect – then you have the **Hexaxial Reference Grid**.

Einthoven did not create the HRG – that was done by a Dr. Bayley (in older literature it is




often referred to as the **Hexaxial Reference Grid of Bayley**). Einthoven only knew of Leads I, II and III. The augmented leads were added later.

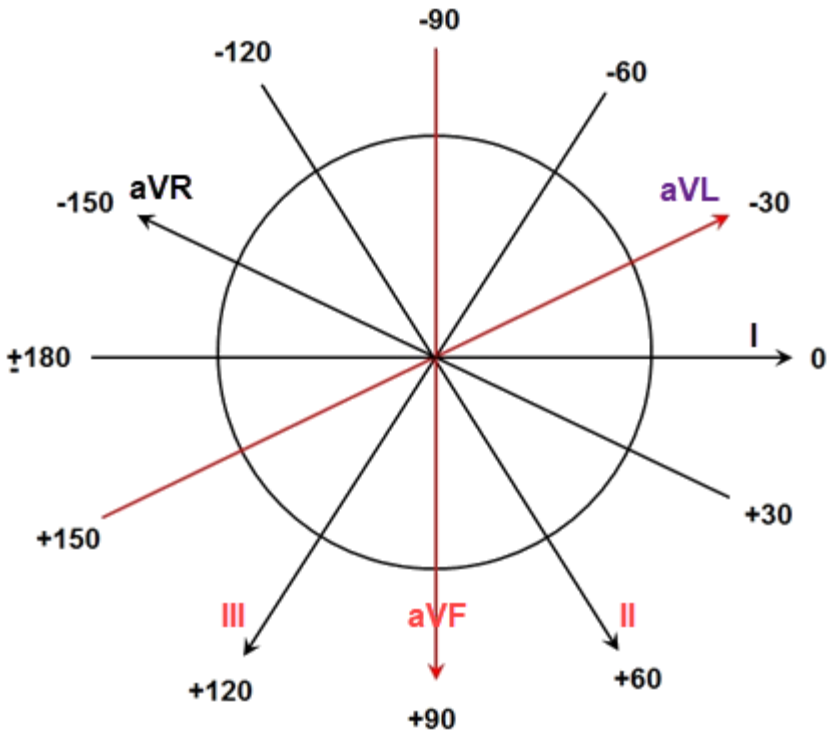
OK, let's take a closer look at the HRG. The first thing that I want you to notice is that all the leads are equidistant from each other – separated by 30°. That is not a coincidence – *that is a result of using an equilateral triangle* and not a scalene triangle.

The inferior leads (II, III and aVF) are grouped together at the bottom because all three leads use the left foot electrode as their positive pole. Note that Leads II and III are NOT really adjacent or contiguous to each other – they are separated by Lead aVF.

We also frequently think of Leads aVR and aVL as being located very high up because their recording electrodes are on the right and left shoulders, respectively. That is really NOT the case: both leads are located just 30° above the horizontal axis of Lead I.

Each lead has a ***positive*** pole and a ***negative*** pole – and *that includes the augmented leads!* For many years we referred to Leads I, II and III as ***bipolar*** leads and Leads aVR, aVL and aVF as ***unipolar*** leads. Well, ***there are <u>NO</u> unipolar leads*** – and that also includes the precordial leads. *All* leads in *both* planes (frontal, horizontal) are *bipolar! All of them!* The term "unipolar" was popularized by Dr. Frank Wilson in 1934 when he created Wilson's Central Terminal which acted as a negative pole for the augmented limb leads (which he also created). Even then, Wilson was fully aware that the term was actually a *misnomer* (and said so!). Today, if you want to refer to Leads aVR, aVL and aVF, use the term **augmented leads** – *not* unipolar leads. The same goes for the precordial leads. If you truly believe in *unipolar* leads, then please show me an AA battery *with only one end!*

As you can see, each of the six leads has a *positive* pole and a *negative* pole. ***Recordings occur only at the positive poles***. So, when you see Lead aVL on the 12-lead ECG, you are seeing what the positive pole of aVL recorded. I have labeled the six leads at their *positive* poles in the illustrations.




Here is another source of confusion that I would like to clear up: the use of the "+" and "–" signs. They have absolutely NO mathematical or algebraic meaning!

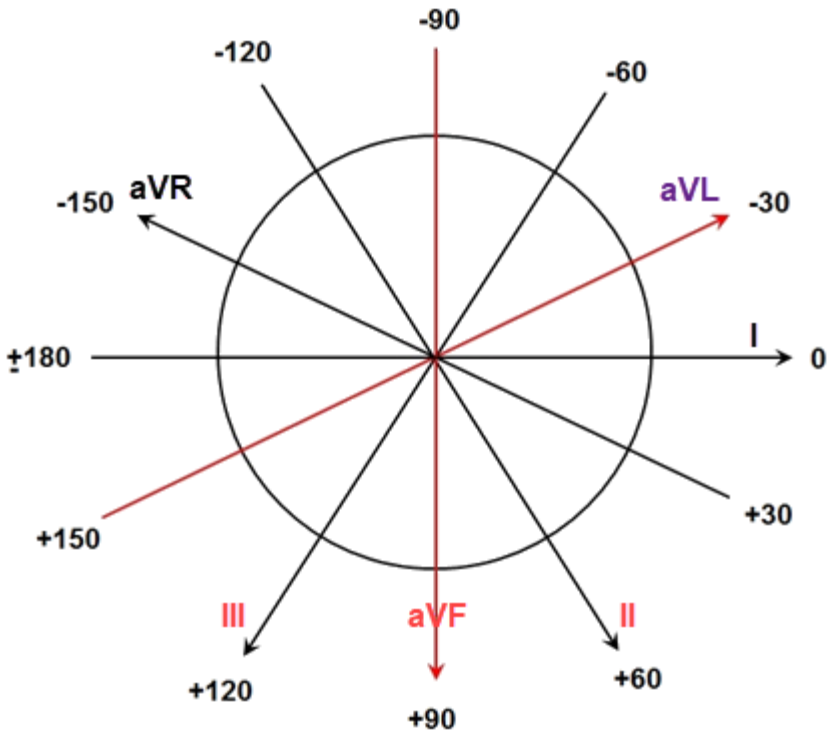
In the beginning, the degrees were listed from 0° to 359°. Quick!… where is a vector pointing at 251°? Kind of difficult to visualize quickly, isn't it? So, a decision was made to divide the HRG into two sections and each would go from 0° to 180°. So, if I asked you to indicate a vector pointing at 30°, it wouldn't take you long to realize "Good grief! Which one does he mean? There are TWO 30° positions on the HRG!"

So, a method was created to distinguish between the degrees ABOVE the Lead I axis located at 0° and the degrees BELOW the Lead I axis. While they could have chosen 30A or 30B or 60α or 60β – they chose to use the plus (+) and minus (−) signs. The plus (+) sign simply means that the designated degree is located BELOW the Lead I axis and the minus (−) sign means that the designated degree is located ABOVE the Lead I axis. The separation between +60° and -30° is NOT 30°; it's 90°! Again, the PLUS and MINUS signs have NO MATHEMATICAL OR ALGEBRAIC FUNCTION! They are used only as symbols for "above" and "below Lead I."

Here is a little view of how knowledge of the HRG can help you while interpreting a 12-lead ECG…

What if Lead III has a very deep S wave – deeper than any S in Leads aVF or II. What is its significance? Well, that would indicate that the mean QRS vector (ÂQRS) is pointing directly (or *almost* directly) *away from* the positive pole of Lead III. From the HRG, we know that the positive pole for Lead III is located just 30° to the right of Lead aVF, at **+120°**. Given that bit of information, we then know that the mean QRS vector must be pointing toward the *negative* pole of Lead III which is located at **-60°**. That is *far* to the left, so we know that a *very significant left axis deviation* is present *whenever we see a deep S wave in Lead III*.

What's the difference between an **axis** and a **vector**? To me, an *axis* is *immutable* and *unchanging* while a *vector* is *moving* and *changing almost every nanosecond*. Each limb lead has an axis that never changes – you will find Lead I in exactly the same place every time you look at the HRG. A mean QRS vector (ÂQRS) is constantly changing. You often read about the




mean QRS *axis* in introductory ECG lessons, but it probably should be called the mean QRS ***vector***!

Recap: the Hexaxial Reference Grid enables us to conceptualize the vectors of ventricular depolarization easily. Dividing the circle into two sets of 180° makes it much easier to quickly visualize in which direction a vector is pointing. The plus and minus signs help us to know immediately on which side of the Lead I axis the vector is pointing. The location of the positive poles of each lead roughly approximates their location on the body.

In Part 2, I will show you how each lead has its own positive and negative area and how to use that knowledge to your advantage. I will also teach you that there is a very good reason and use for determining the mean QRS vector and *how and when to use that information*. It really isn't just a time-wasting exercise. Personally, I always found it very frustrating when instructors would have me determine the mean QRS vector on a 12-lead ECG and then not be able to tell me why I needed to know that information, or else give me vague and useless responses like "it's the average direction of the cardiac impulse." (I could already see that just from the *name* alone!). Here's a Spoiler Alert: we rarely ever determine the mean QRS axis just to know what it is. We use it to understand what is happening in the different leads and why each lead looks the way it does. For instance, Lead III can look completely different in four separate ECGs – and yet be considered NORMAL in each one. To understand why that is so, you will need to know the mean QRS vector.

Here are a couple of ***lagniappes*** (a little something extra) for you…

**First**, no two leads in the frontal plane can be 180° away from each other. If you look at Lead aVF, for instance, 180° away from the positive pole of Lead aVF is… Lead aVF! The furthest apart two leads can get in the frontal plane is 150°, which happens to be the separation between Leads III and aVL. (This becomes *very* important later!)

**Second**, without looking, where is the *negative* pole for Lead II? It's simple – as long as you know where the *positive* pole for Lead II is located (**+60°**). Just subtract 60 from 180 and you get 120. Then apply the opposite sign. The negative pole of Lead II is located at **-120°**.