

Some ECG Subtleties Using Vectors...

27-Sep-1976
Male

Vent. rate 69 bpm
PR interval 136 ms
QRS duration 90 ms
QT/QTc 400/428 ms
P-R-T axes 30 45 54

Normal sinus rhythm
Normal ECG

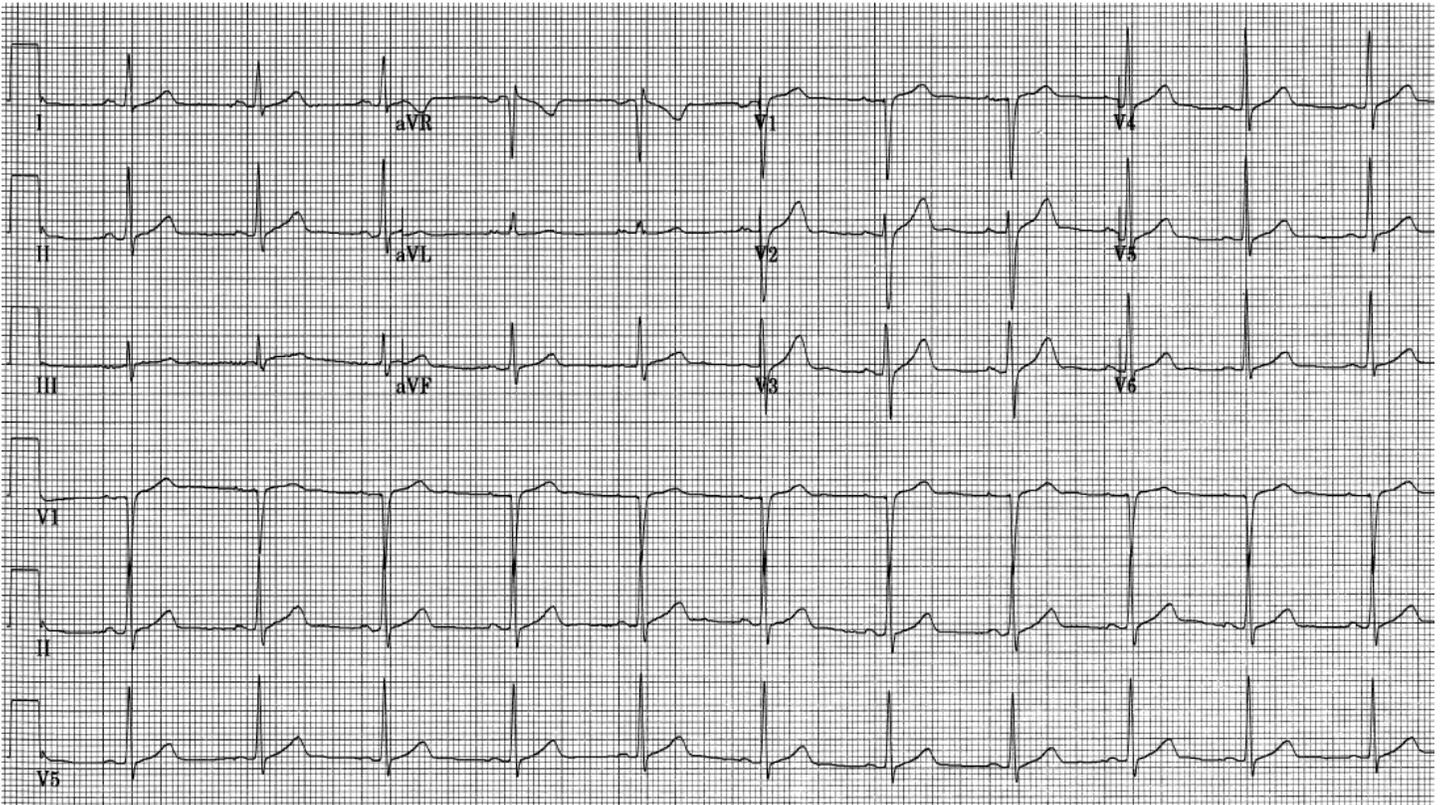


Figure 1

The ECG machine has interpreted this ECG as “Normal sinus rhythm” and “Normal ECG.” I would agree, but I would caution you against trusting the ECG machine interpretation just because *some* of its interpretations are correct. Don’t let your guard down.

Let’s look at the P waves and why this is sinus rhythm. The first criteria for sinus rhythm are *upright P waves in Leads I and II*. Recall that a positive deflection in a lead means that the impulse is traveling *toward* the positive pole of that lead. Therefore, you know which direction that impulse is traveling, *but only if you know where the positive pole for that lead is located*. That is why it is so very important to know the **Hexaxial Reference Grid** thoroughly. The Hexaxial Reference Grid is composed of all six limb leads intersecting at a common point. Here is the Hexaxial Reference Grid (next page):

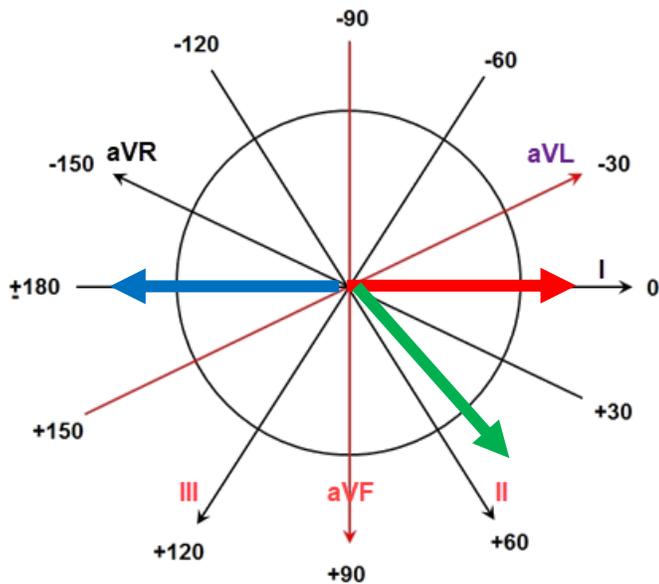


Figure 2

impulse traveling *away from* the positive pole of a lead will create a negative (or inverted) deflection in that lead. In electrocardiography, we discuss polarity in terms of an impulse's orientation to the POSITIVE pole only. We do not discuss the negative pole. Every lead has *both* a *positive* and a *negative* pole – there really are NO “unipolar” leads which in electrocardiography would be an impossibility. The researcher who first used the term “unipolar” knew (and stated) that it was a misnomer. Can you show me an AA battery with only a positive end?

Just like an impulse traveling *toward* a positive pole, an impulse traveling *away from* a positive pole will be greatest when it is traveling *directly* away from the positive pole.

In Figure 2, the red arrow is traveling *directly toward* the positive pole of Lead I; therefore, it will inscribe the largest R (or P) wave in Lead I. The blue arrow is traveling *directly away from* the positive pole of Lead I; therefore, it will inscribe the deepest S (or P) wave in Lead I.

The green arrow is still traveling toward the positive pole of Lead I, but not as directly. In fact, it is traveling more directly toward the positive pole of Lead II. So, the R (or P) wave in Lead I will not be as tall as the R (or P) wave in Lead II, though it certainly remains a positive deflection.

The Hexaxial Reference Grid can be used for P waves, QRS complexes, ST segment vectors and T waves. It is very important that you memorize this figure.

Now let's get back to the ECG...

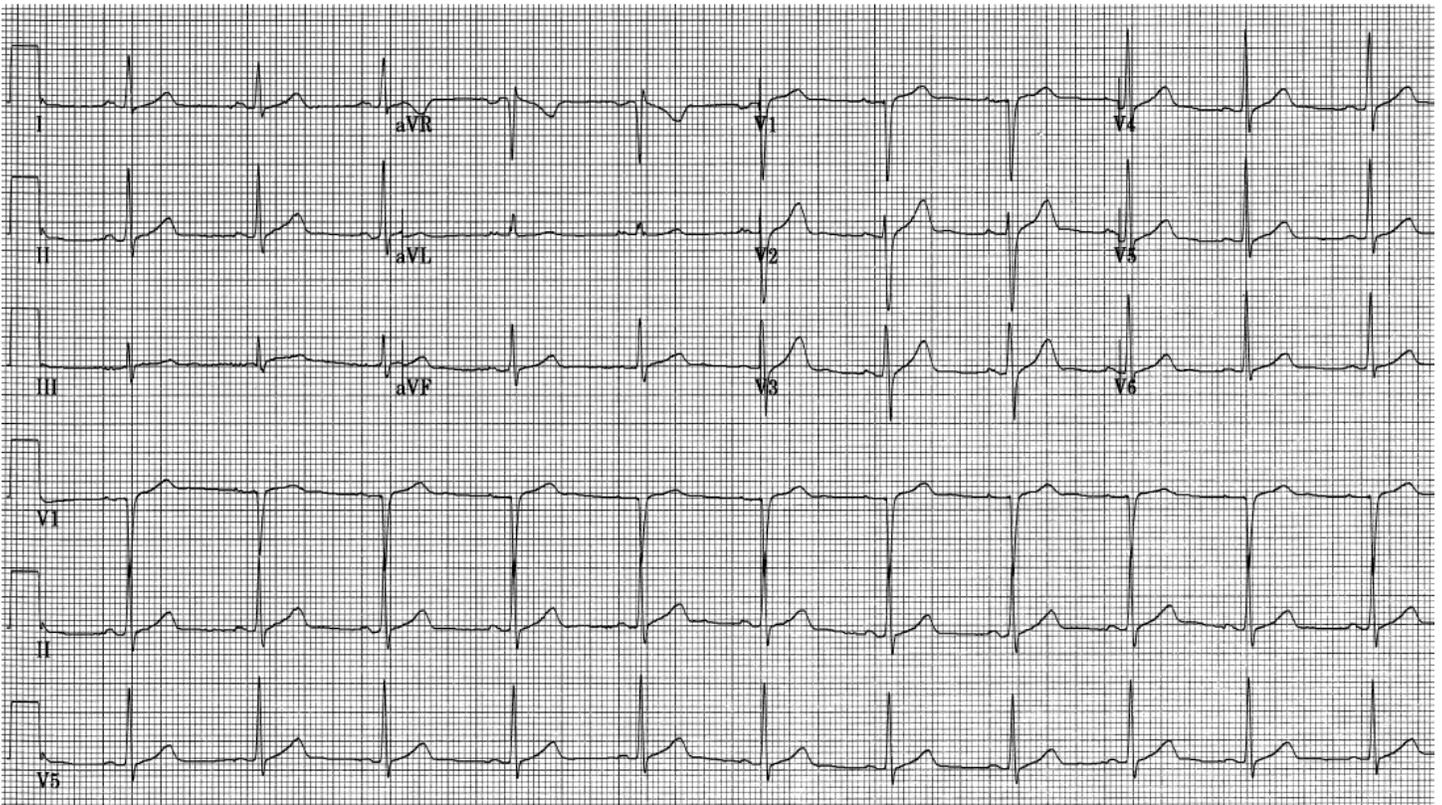
I have labeled the positive poles of each of the lead axes with the name of the lead. The positive pole for Lead I is 0°, the positive pole of Lead II is +60°, etc.

So now you know why an upright P wave in Lead I means the atrial impulse is traveling to the LEFT, toward the positive pole of Lead I. A P wave originating in the sinus node must travel LEFT to activate the left atrium.

The more directly an impulse travels *toward* the positive pole of a lead, the larger that positive impulse will appear in that lead. Likewise, an

Figure 1 (repeated)

27-Sep-1976	Vent. rate	69 bpm	Normal sinus rhythm
Male	PR interval	136 ms	Normal ECG
	QRS duration	90 ms	
	QT/QTc	400/428 ms	
	P-R-T axes	30 45 54	



Again, since the P waves in Leads I and II are both upright, we can consider this to be a sinus rhythm. Is it *absolute proof* that sinus rhythm is present? NO! An ectopic atrial pacemaker focus located very near the sinus node would produce the *same result*. It just tells us that the atrial impulse is coming from the upper part of the right atrium. I always look for a +/- biphasic P wave in Lead V1, but there is a monophasic upright P wave on *this* ECG. Don't worry about it; as long as we have that upright P wave in Lead I, we KNOW that the P wave is originating in the right atrium. Does a +/- biphasic P wave in Lead V1 prove sinus rhythm? NO! It just confirms that the atrial impulse is originating in the right atrium. Though the ECG findings that we use to ascertain whether or not a sinus rhythm is present are what many would call "soft signs," *those are still the findings that you should use.*

Look at the P wave in Lead III. Uh-oh... *there is no visible P wave in Lead III!* What does that mean? It means that the $\hat{A}P$ (mean P wave) vector is traveling *exactly* perpendicular to Lead III. An impulse traveling perpendicular to a lead is crossing it right at that point where the positive pole of the lead is seeing the impulse turn from positive (traveling toward it) to negative (traveling away from it). Since the vector is exactly perpendicular, it is doing neither, thus

27-Sep-1976
Male

Vent. rate 69 bpm
PR interval 136 ms
QRS duration 90 ms
QT/QTc 400/428 ms
P-R-T axes 30 45 54

Normal sinus rhythm
Normal ECG

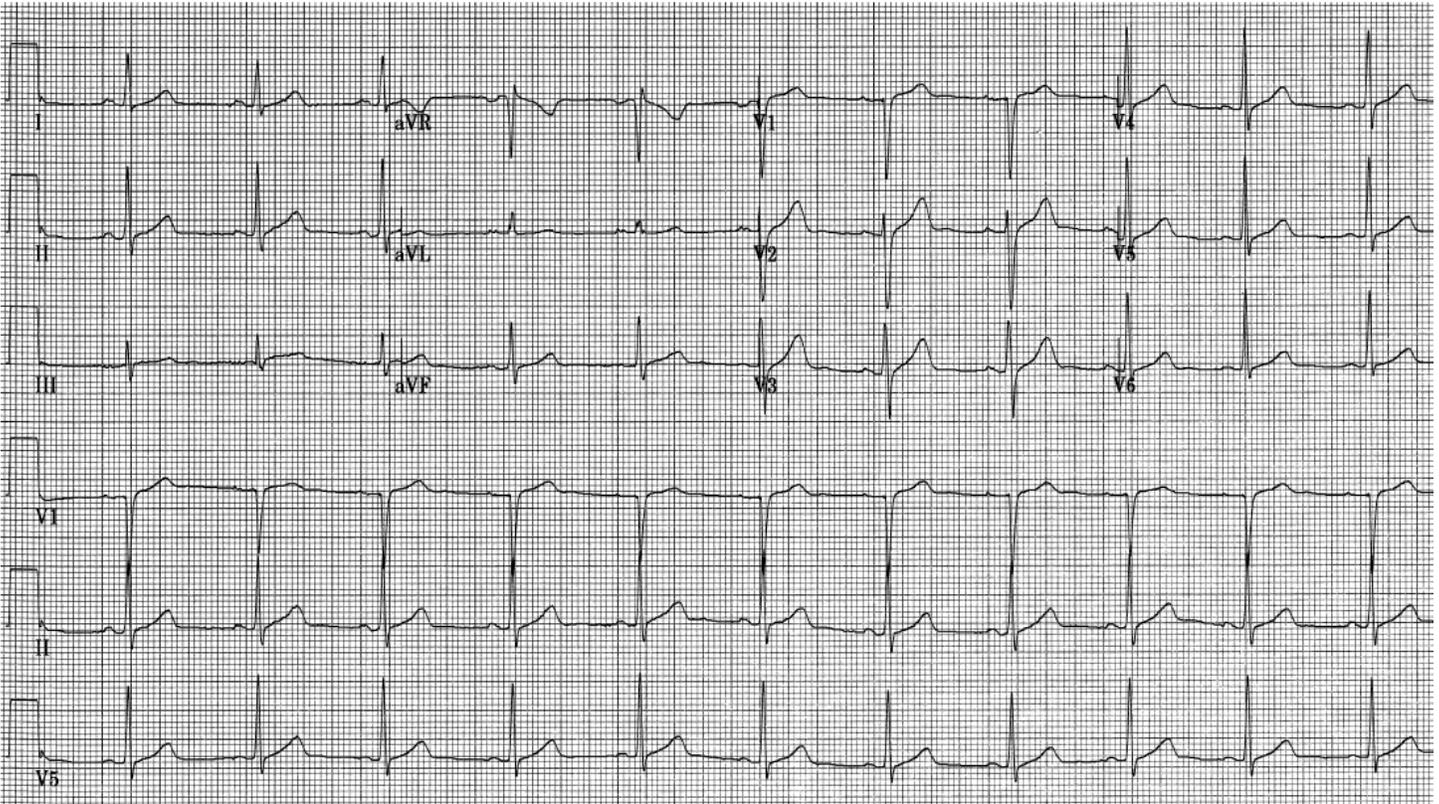


Figure 1 (repeated)

nothing representing that deflection appears in that lead. **A vector that is perpendicular to a lead is invisible to that lead.**

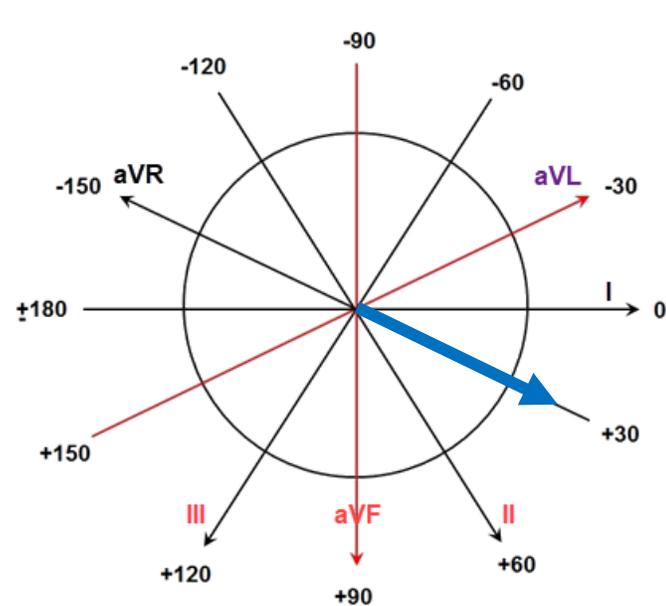


Figure 3

Well, if the $\hat{A}P$ vector is perpendicular to Lead III, then it must be pointing directly toward $+30^\circ$, which is the negative pole of Lead aVR (Leads III and aVR are perpendicular to each other). Because we don't normally use the negative poles of leads (actually, *advanced ECG* interpreters *do* use the negative poles at times), that means that the $\hat{A}P$ vector is traveling directly toward the pole at $+30^\circ$ (which is the *negative* pole for Lead aVR). That also means that the vector is traveling *directly away from the positive pole of Lead aVR* and so it should be maximally negative (blue arrow, Fig. 3).

Recall that the “+” and “-” figures in front of the number of degrees have *no connection* to whether a lead pole is positive or negative. Lead aVR has its POSITIVE pole at -150° and its NEGATIVE pole at $+30^\circ$.

We normally say that Lead II should have the largest P waves on the ECG, but that is because most $\hat{A}P$ vectors tend to hover around $+60^\circ$, which is the positive pole of Lead II. With this patient, the $\hat{A}P$ vector is pointing directly at $+30^\circ$ which makes the negative P wave in Lead aVR officially the largest P wave on the ECG (though it’s difficult to see that).

Here is an observation I’ve seen again and again during my teaching: people tend to focus more on POSITIVE deflections than on NEGATIVE deflections. They are much more apt to note changes in a positive deflection than those in a negative deflection. *Don’t make that mistake!* **Polarity on a 12-lead ECG simply indicates DIRECTION – not IMPORTANCE or PRIORITY!**

Two more observations on this normal ECG...

It is very important that you note the size of the T waves in each lead in relation to the amplitude of the QRS (again, amplitude includes both *positive* and *negative* deflections). It is good to start getting some experience in recognizing normal T waves as opposed to abnormal (especially hyperacute) T waves. In acute situations, you will often *not* have a previous ECG to use as a reference, so you will have to decide on the normality of a T wave with just one ECG. There are three things to pay particular attention to:

1. The height or depth of the T wave compared to the total amplitude of the QRS
2. The width of the base of the T wave
3. Whether or not the T wave is symmetrical or asymmetrical (asymmetrical is normal)

You really have to closely scrutinize a lot of normal ECGs to understand what *is* and what is *not* normal. As I said, you will likely have to make your decision based on what you remember from seeing a lot of normal ECGs *because there are no objective measurements to help you.*

I hope you learned a bit about the Hexaxial Reference Grid. If you want to interpret 12-lead ECGs above the introductory level, you *must* know that grid *thoroughly!*

Also, a reminder that I do provide 1-on-1 private tutoring or consultation sessions via Zoom. Just go to my website to sign-up...

<https://medicusofhouston.com/online-private-tutorial-sessions/>

Come join us and be a *PARTICIPANT*... never just an audience!