A 12-Lead ECG for the Newbies

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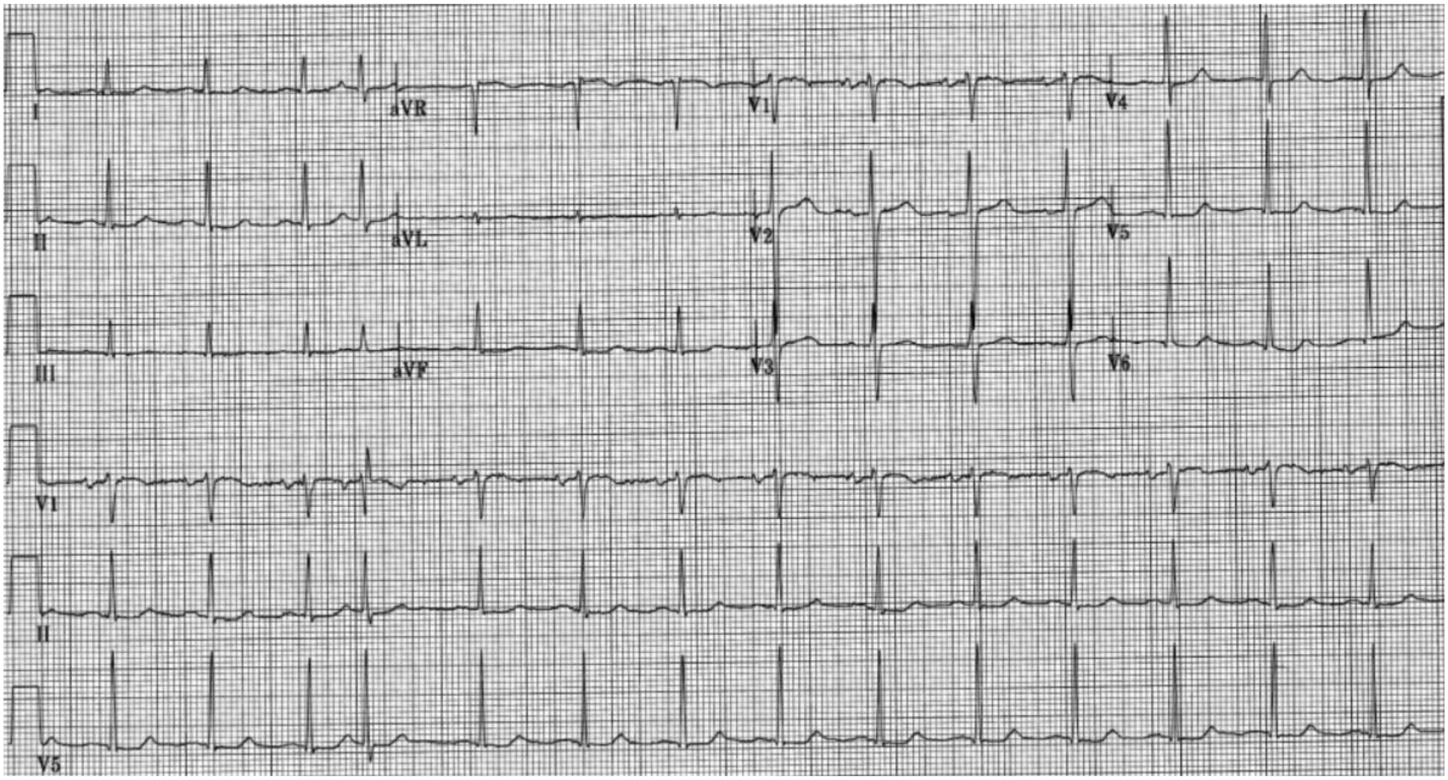


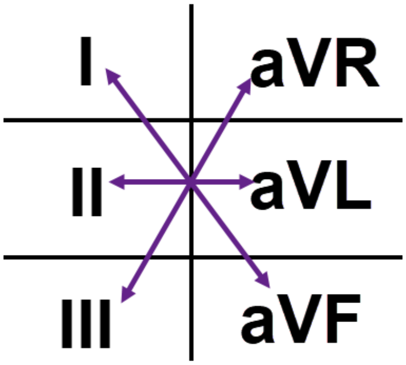
Figure 1

This is an ECG from my collection and it was recorded on an 88 year old woman. I do not know why the ECG was done.

The rhythm is sinus and the rate is 88 and regular except for one premature beat. There is no evidence of any acute process occurring here.

Let's begin by looking at Leads II and aVL. What do you notice here? Well, there is a tall R wave in Lead II. In fact, it's the tallest R wave of all the **limb leads** (Leads I, II, II, aVR, aVL and aVF). That tells me that the **mean QRS vector in the frontal plane** (ÂQRS) is pointing at (or very near) Lead II. The positive pole of Lead II is located at +60°on the Hexaxial Reference Grid. The ECG machine measured the ÂQRS to be +59°. If Lead II has the tallest R wave, then the lead axis that is *perpendicular* to Lead II will have the smallest. Lead aVL is perpendicular to Lead II. You should have easily guessed that from its appearance!

Are you having trouble remembering which leads are perpendicular to each other? Then just remember this diagram:



It looks like a game of "tic-tac-toe." As you can see, Leads II and aVL are connected, so they are perpendicular to each other. That means that as one gets larger, the other gets proportionally smaller. It's easy to remember this diagram because the leads are presented the same way as on a 12-lead ECG. So, Leads III and aVR are perpendicular and Leads I and aVF are also perpendicular. Notice that no two **standard leads** (I, II and III) are perpendicular to each other. The same applies to the **augmented leads** (aVR, aVL and aVF). It is always *one standard lead* and *one augmented lead* that are perpendicular to each other.

There is an inherent problem here…

MOST mean QRS axes in the frontal plane tend to cluster around +60°. That means that Lead aVL is often so small that it is almost uninterpretable. What if the patient is having an acute basolateral myocardial infarction? What if Lead aVL is – at the moment you obtain the ECG – the only lead manifesting ST elevation? It's going to be very difficult to see that, isn't it? That is why I always say that ***Lead aVL is the most dangerous lead*** on the 12-lead ECG – because it's so easy to miss something important.

We always say, "Repolarization is proportional to depolarization." How can the ST segment be elevated very much when the QRS is so tiny? Look at Lead aVL on this ECG and imagine an ST elevation that extended to the top of that miniscule R wave. It would be easy to miss, wouldn't it? OK… now imagine an ST elevation that is 50% the height of the R wave… or 25% the height of the R wave. That is why I say that if you want to be serious about reading ECGs you should have a small magnifying lens available. Now do you see how an ST elevation that extends the full height of an R wave may not meet today's standard of 1 mm or 2 mm of elevation?

OK… let's move on. There is a premature beat near the beginning of the ECG. It has a narrow QRS complex. That tells us that 1) the impulse has originated above the division of the His bundle into the right and left bundle branches and 2) that it arrived at the division after the bundle branches have had time to recover from their refractoriness from the previous beat.

There are two kinds of premature beats that can present this way (normal-appearing QRS complex): a premature atrial complex (PAC) and a premature junctional complex (PJC). Look closely and see if you can determine which it is.

It is a PAC. While you should look closely at the premature QRS complex, *you should look even closer at the T wave that precedes it*. You will see that it is slightly larger than all the other T waves in the same lead. It's a subtle difference, but it is visible. It's larger because it has had some POSITIVE voltage added to it – an upright P′ wave. We use the term P′ ("P-prime") when the P wave did not originate in the sinus node. In this case, it originated in an atrial ectopic focus. Now, if you look even closer, you will see that the narrow QRS complex is not *exactly* like the other QRS complexes in the same lead – it is slightly different. If you look in Lead V1, you will see that it is *very* different there. So there is a very slight amount of *aberrant conduction* occurring here.

We say an impulse is *aberrant* when it arrives at the bundle branches during a relative or absolute refractory period. This PAC likely arrived very near the end of the refractory period of the right bundle branch.

There is a probable lead wire switch on this ECG. Did you notice it? Look at Lead V2. Would it not seem more appropriate if it were Lead V3 and Lead V3 were Lead V2? This happens very frequently, and especially with those two leads (V2 and V3).

There is ST flattening throughout the ECG and even a bit of ST depression in places. These are likely chronic changes in an 88 year old, but we would need more information to actually say that. But we don't have any more information. So… when we see repolarization changes that we cannot confidently explain, what do we call them? **Nonspecific ST-T changes**.

I appreciate your readership very much. Thank you all!

Is there something you're just not understanding?

Are you having difficulty reading and interpreting ECGs? Do you find yourself depending on the machine interpretations? Have you experienced a "bad outcome" because an ECG was misinterpreted? Have your ECG interpretation skills come to the attention of your hospital's peer review committee?

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