Why Is Lead III So Odd?

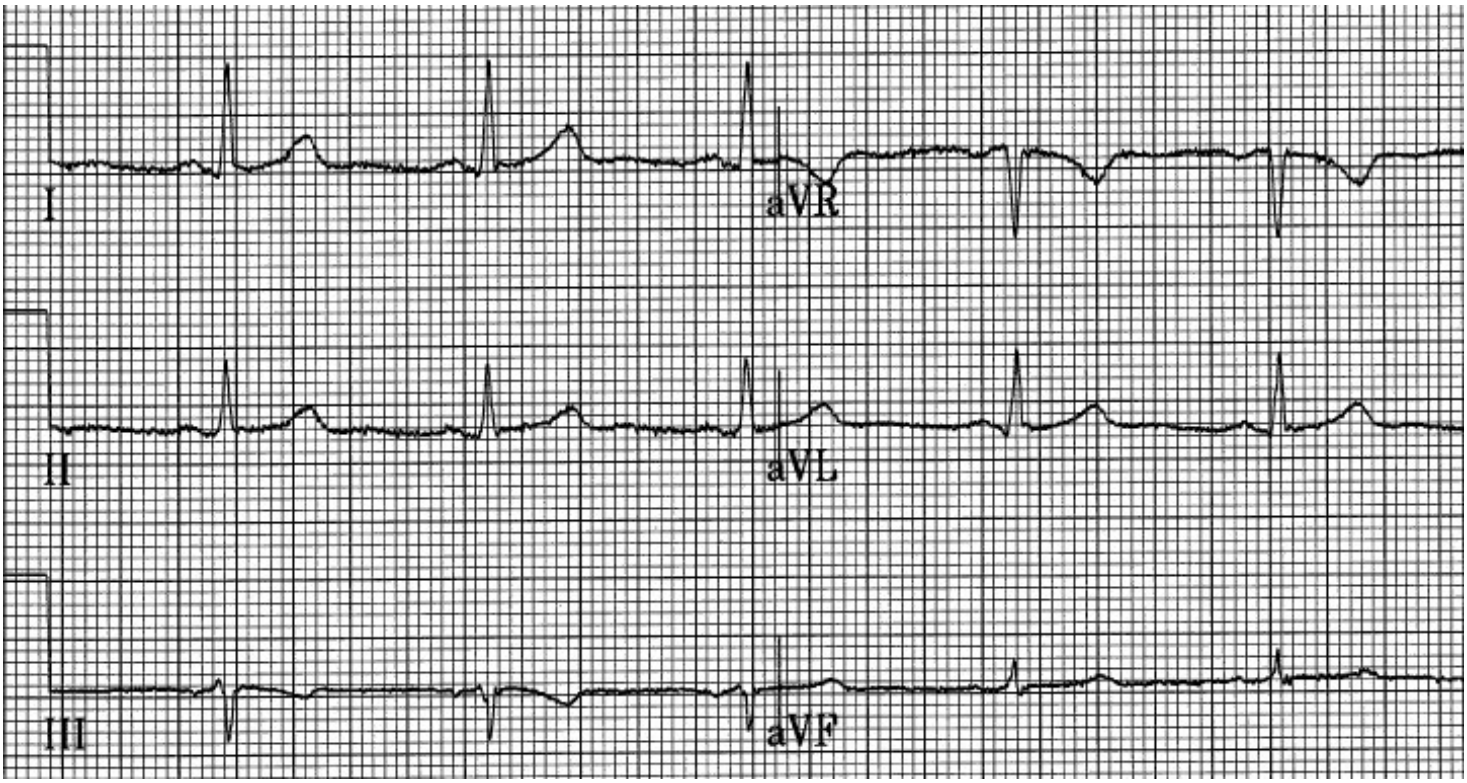

Figure 1

This is from another of my ECGs selected at random. For this ECG, I want to discuss something that a lot of people have difficulty with when interpreting a 12-lead ECG: ***Lead III.***

When the ECG is essentially normal, Lead III sometimes acts like a "lone wolf," often having a very different appearance than its other associated inferior leads (Lead II and Lead aVF), as in the ECG in Figure 1. This causes some confusion at times and leads the person interpreting the ECG to wonder if they are missing something. If leads II and aVF appear unremarkable, then it is most likely that nothing is being missed! But why does this happen?

Some of you may not realize it, but when a 12-lead ECG is recorded, only TWO of the limb leads are actually recorded. Those two limb leads are **Leads I and II**. Leads III, aVR, aVL and aVF are all calculated by the ECG machine using Einthoven's Law: **Lead II = Lead I + Lead III**.

To simplify the calculation for Lead III, Lead III is the result of Lead aVF – Lead aVL. But there's also an even easier way to understand what is happening in Lead III…

PEARL!

Any deflection in Lead aVL that has a greater magnitude than the corresponding deflection in Lead aVF will appear in Lead III on the opposite side of the baseline.

Let's take a look at Figure 1.

Since the positive R wave in aVL is greater in magnitude than the positive R wave in Lead aVF, we would expect the corresponding deflection in Lead III to appear on the opposite side of the baseline – *and it does!* Instead of an R wave, Lead III has an S wave. But note that the S wave in Lead III does not have the same magnitude as the R wave in Lead aVL. That's because Lead aVF has a small R wave which has contributed a bit of positive area to the deflection. The point to understand here is that neither Lead aVL nor Lead aVF need be negative for Lead III to be negative. If a QS in Lead aVL were *deeper* (had greater magnitude) than a QS in Lead aVF, it would appear in Lead III as an upright, monophasic R wave.

Since the *upright* T wave in Lead aVL has greater magnitude than the *upright* T wave in Lead aVF, we would expect the T wave in Lead III to be on the opposite side of the baseline – *and it is!* The T wave in Lead III is *inverted* (*negative*). Again, the T wave in Lead III does not have the magnitude of the T wave in Lead aVL because Lead aVF also has a small upright T wave which adds a little positivity.

Taking this a bit further, we can see that Lead aVL has a very small q wave while Lead aVF has none. Therefore, the QRS interval in Lead III begins with a very small r wave.

This is the main reason that Lead III often looks a bit "out of place" with its neighbors when the ECG is otherwise mostly normal. If there is an acute MI, however, it will usually resemble the other inferior leads (Figure 2)…

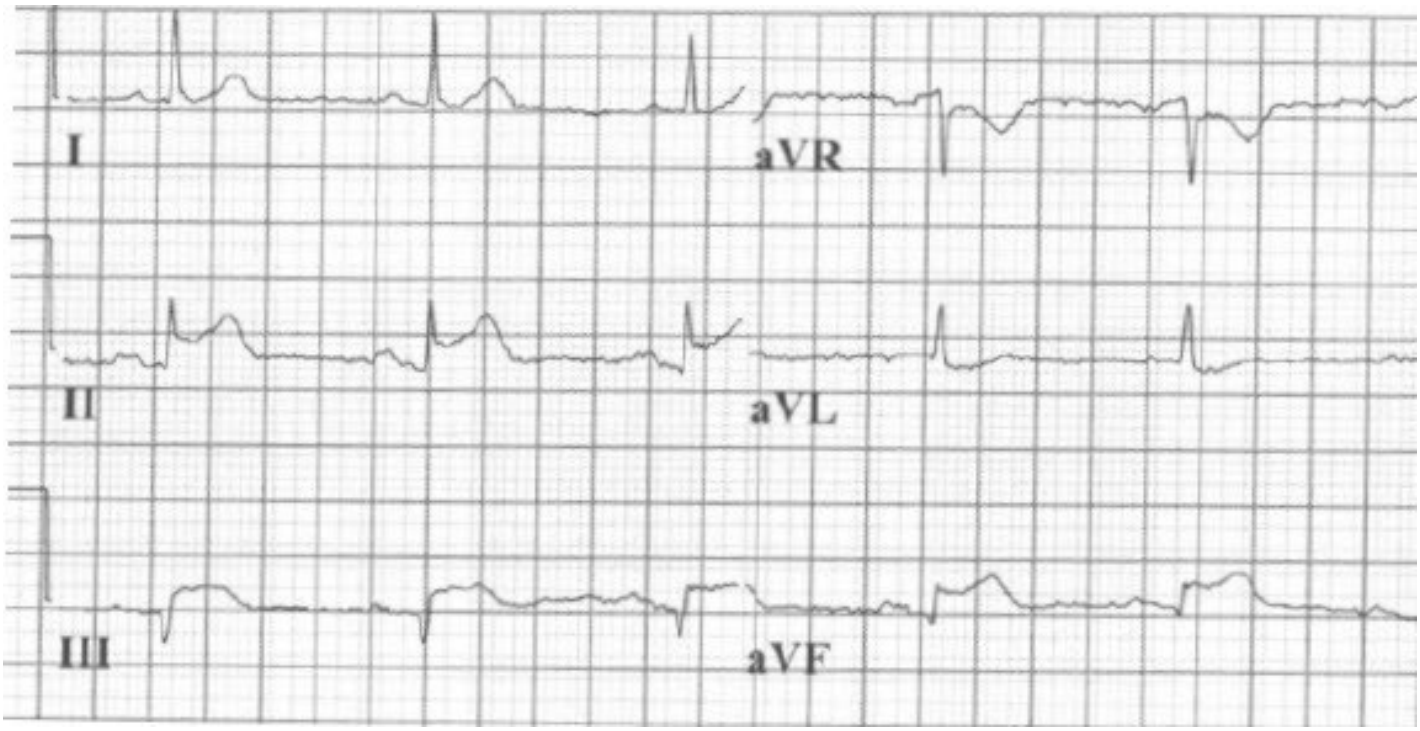

Figure 2

In this case, Lead III manifests the same STE as seen in Leads II and aVF. However, you may have noticed that Einthoven's Law (comparing Lead aVL with Lead aVF) still pertains.

If Lead III looks a bit worrisome, but Leads II and aVF look perfectly normal – don't worry about it. It's just a result of the mathematics of Einthoven's Law!