Diagnosing Lead Wire Switches (Interchanges)

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Are you tired of memorizing which leads *invert* during certain lead wire switches (aka “lead wire reversals” or “lead wired interchanges”)?

Are you tired of memorizing which leads *switch places*?

Are you tired of memorizing which leads invert *and* switch places?

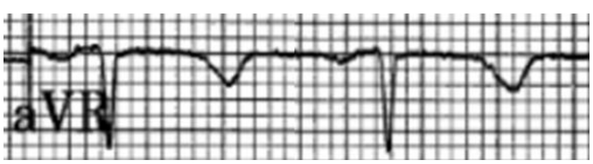
Are you simply tired of memorizing?

You don’t have to memorize *anything!* I developed (actually, I stumbled upon) what I now call the **JONES Method** for diagnosing lead wire switches when I was an attending physician in the emergency department of the hospital for the Texas Heart Institute in Houston, Texas.

It’s easy, accurate and reliable. And you only deal with the same two leads for each lead wire switch – Lead aVR and Lead II. In fact, you will use Lead II in only one instance.

There are only THREE things you must know before using the **JONES Method**: first, how to recognize the typical P-QRS-T for Lead aVR, 2) the fact that each electrode is actually an *augmented* lead and 3) the limb leads have restrictions on the leads with which they can switch. Let’s take a look…

1. Recognizing a Normal P-QRS-T in Lead aVR



The Lead aVR snippet on the left manifests a normal QRS-T complex (*normal for Lead aVR!*). All deflections are inverted: the P wave, the QRS and the T wave.

2. The Three Limb Lead Electrodes ARE the Augmented Leads!

aVR = **RA** (right arm/shoulder)
aVL = **LA** (left arm/shoulder)
aVF = **LF** or **LL** (left foot/leg)   I prefer **LF** so that is the designation I will use.

3. A Lead Cannot Switch With Just ANY Other Lead!

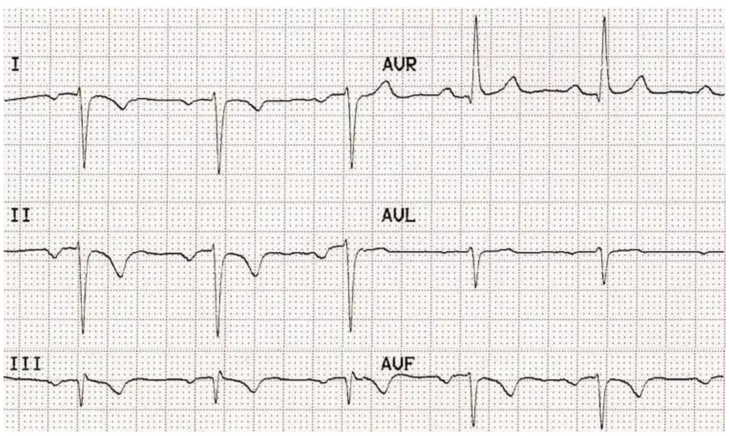
The **LIMB LEADS** are divided into **STANDARD** and **AUGMENTED** leads. The **STANDARD LEADS** are Leads I, II and III. The **AUGMENTED LEADS** are Leads aVR, aVL and aVF.

STANDARD leads can only switch with STANDARD leads and AUGMENTED leads only switch with AUGMENTED leads. For example, Lead aVR cannot switch with Lead I, II or III. Conversely, Lead II cannot switch with Lead aVR, aVL or aVF.

OK… you now know how to recognize a normal Lead aVR. You have learned that we can call Lead aVR "RA electrode", Lead aVL "LA electrode" and Lead aVF "LF electrode" and that *standard leads can switch only with other standard leads* and *augmented leads can switch only with other augmented leads*. Good… let's get started (after this quick disclaimer):

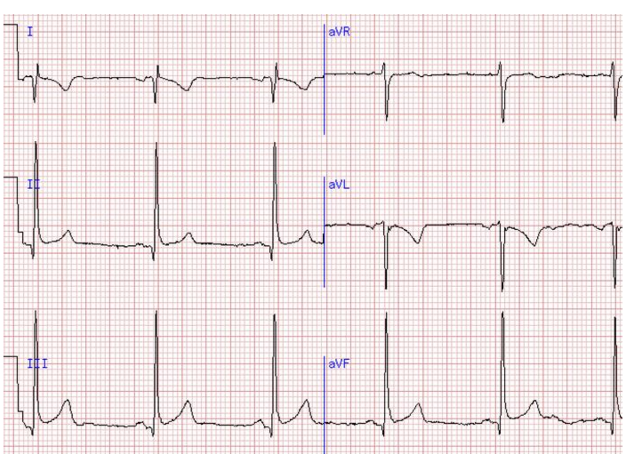
The ***JONES method*** *does NOT include lead wire interchanges involving the right foot (neutral) wire. Such changes are very characteristic and very easy to recognize. The* ***JONES method*** *only addresses lead wire interchanges involving the three limb electrodes (RA, LA and LF).*

Let's look at an example of a lead wire interchange (we will only be looking at the *limb leads* since the precordial leads are not involved in this method)…



Many of you may have already recognized this as a LA/RA lead wire switch by the inverted P wave in Lead I. If so, keep that thought in mind as we look at some other examples to learn from.

The **JONES method** is a bit like an algorithm that you can use to diagnose a lead wire switch (sometimes called a "lead wire interchange"). Until now, articles written on the topic were mostly detailed analyses, descriptions and trigonometric calculations explaining how the lead wire switch occurred and what you must do to diagnose it… *but no more!*



Here is another example of a lead wire switch…

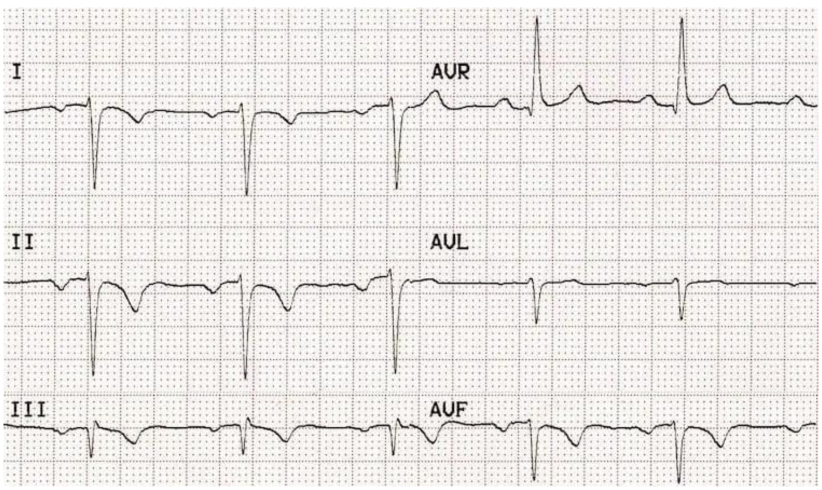
Now let's use the **JONES method**…

1. Where is Lead aVR *actually* located on this ECG snippet? Remember: if it has switched places with another lead it can only be with **Lead aVL ("LA")** or **Lead aVF ("LF")**. If we look in the space reserved for Lead aVR, we see a complex with an upright P wave, an rS morphology for the QRS complex and an upright T wave. If you recall, that is certainly NOT a classic, normal QRS complex for Lead aVR. If we look in the space for Lead aVL we find a negative P wave, a negative QRS complex and a negative T wave – all *classic* for Lead aVR. So we have found the *real Lead aVR* in the space reserved for *Lead aVL*! ***Lead aVR and Lead aVL have switched places***.

2. Remember that we can call Lead aVR "the RA electrode" and Lead aVL "the LA electrode" so this is an RA/LA lead wire switch.

You didn't have to memorize anything – all you had to do was recognize that the real Lead aVR was not in its proper space *which indicated the presence of a lead wire switch!* When you located the *real* Lead aVR, you found it in the space labelled "aVL." Remembering that **aVR = RA** and **aVL = LA**, you were then able to diagnose an RA/LA lead wire switch. You didn't even have to look at any of the standard leads (I, II or III). And that's a good thing! Here's why…

Let's look at the very first ECG snippet that I think many of you diagnosed as a RA/LA lead wire switch based on the inverted deflections in Lead I.



The RA/LA lead wire switch is said to be the easiest to recognize based on the inverted P wave, negative QRS and inverted T wave in Lead I. And I'm sure that many of you recognized it fairly quickly. There's just one problem…

This is NOT an RA/LA lead wire switch! Had you used the **JONES method**, you would not have made that "newbie" mistake!

Back to the JONES method: Is the *real* Lead aVR in its correct space and, if not, where is it? We look in the space labelled "aVR" and see an upright P wave, a very tall R wave and an upright T wave. That, obviously, is NOT the real Lead aVR! Well, if it isn't in the space for "aVR" then it must have switched places with either Lead aVL or Lead aVF. All the standard leads (I, II and III) look *exactly* like a classic Lead aVR but they don't represent Lead aVR! Why? ***Because augmented leads cannot switch places with standard leads!***

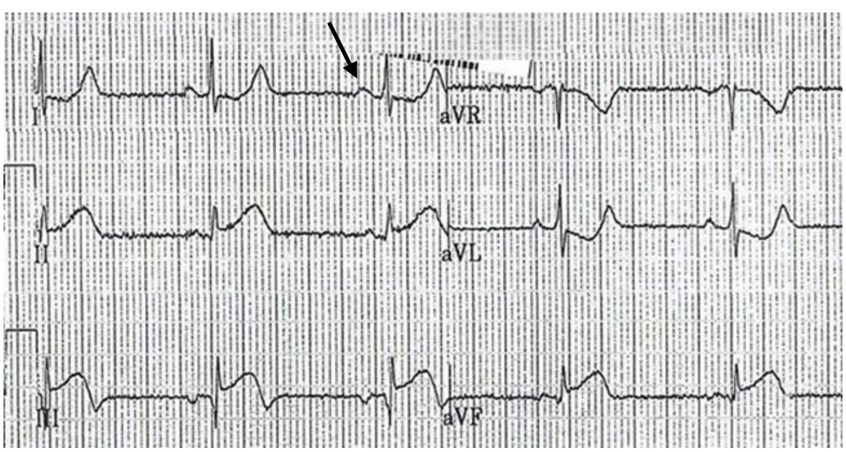
If we look in Lead aVL we see a near-isoelectric P wave (but it's probably slightly negative), a negative QRS complex and an upright T wave. That's not characteristic of Lead aVR! Well, if Lead aVR is not in its proper space and not in the space for Lead aVL then it MUST be located in the space for Lead aVF. When we look at Lead aVF, we see an inverted P wave, a negative QRS and an inverted T wave – ***classic Lead aVR!*** So we see that Lead aVR has switched places with Lead aVF. Again, **aVR = RA** and **aVF = LF**, so we have an RA/LF lead wire switch (or interchange) – NOT an RA/LA lead wire switch!

The problem that arises when you try to diagnose a lead wire switch using inverted deflections in Lead I, or any other standard lead, is that two different lead wire interchanges can cause the same inverted deflections in some of the standard leads. Using the **JONES method**, you shouldn't make that mistake.

So the* JONES method *consists of finding the real Lead aVR. If it isn't in its proper space, then in whichever space you find it – that's the lead with which it switched!

OK, that takes care of the two lead wire switches that involve Lead aVR but there's still one more lead wire switch that *doesn't* involve Lead aVR – a left arm / left foot (LA/LF) lead wire switch. This is said to be the most difficult lead wire switch to detect because Leads aVL and aVF often look somewhat similar. So, switching them is apt to go unnoticed – especially since Lead aVR is located in its proper space. In fact, this lead wire switch has been known to result in an ECG that actually looked *better* than the correctly recorded ECG!

But if you have been approaching ECGs in a very methodical manner, you should have been immediately suspicious of a LA/LF lead wire switch. When you begin reading an ECG, what is the first thing you do? *You check the rhythm!* Is it sinus rhythm or some other rhythm? And what do we look for to determine sinus rhythm? We look for ***upright P waves in Leads I and II*** and we also look to see if ***the P wave in Lead II is the <u>largest</u>***. This is the best indicator that the P wave axis is pointing towards the positive pole of Lead II and therefore coming from the area of the sinus node. In an LA/LF lead wire switch, not only do Leads aVL and aVF switch places, *so do Leads I and II**. If, while checking to see if sinus rhythm is present, you notice that the P wave in Lead I is visibly larger than the P wave in Lead II – though *both* will likely be upright – you have not only diagnosed a lead wire interchange, you have *specifically* diagnosed a **LA/LF lead wire interchange!**



Here is a *real* LA/LF lead wire switch. As you can see, Lead aVR is exactly where it is supposed to be. But if you look closely at Leads I and II, you can easily see that the P wave in Lead I is quite visibly larger than the P wave in Lead II.

This snippet also illustrates the effect that a lead wire interchange can have on patient management. This ECG looks like the patient is having an acute inferior MI with reciprocal changes in Leads I and aVL. If the lead wires are changed to their *correct* electrodes, the ECG would then manifest an acute basolateral MI with reciprocal changes in the inferior leads – the patient's *true* diagnosis.

Often reports appear on ECG blogs and in periodicals about cases in which a patient comes to the emergency room, an ECG is recorded and the patient has an acute inferior MI (or acute basolateral MI). Then, for some reason, the patient is disconnected from the ECG machine and later reattached for another 12-lead ECG, only to find that the acute MI has moved to a different area. **Spoiler Alert:** it's always a lead wire switch and often a LA/LF lead wire switch.

When using the **JONES method** in two of the three lead wire interchanges involving the limb lead electrodes, you will use only Lead aVR. For the third lead wire switch that involves Leads aVL and aVF (but NOT aVR), diagnosis will depend on locating Lead II which you will recognize because it will have the largest P wave. This should actually occur as you begin to interpret the ECG and check the rhythm.

IN A NUTSHELL…

Before interpreting an ECG, always check for improper electrode placement.
1. Is Lead aVR in its correct place on the ECG?
2. Does Lead II have the largest P waves of all the limb leads?

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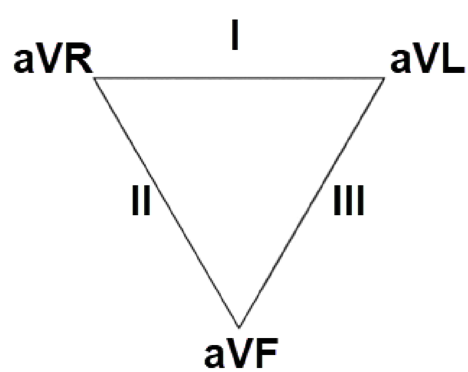
*When two electrodes are switched, two **AUGMENTED** leads will switch places with each other and two **STANDARD** leads will also switch places with each other. Here is an example using Einthoven's Triangle:



If the RA and LA electrodes are switched, 3 things will happen:

1. Leads aVR and aVL will switch places on the ECG.
2. Lead I will reverse its polarity 180° since its positive and negative poles have switched places.
3. Leads II and III will switch places because each lead is attached to an electrode involved in the switch.

If the LA and LF electrodes are switched, 3 things will happen:

1. Leads aVL and aVF will switch places on the ECG.
2. Lead III will reverse its polarity 180° since its positive and negative poles have switched places.
3. Leads I and II will switch places because each lead is attached to an electrode involved in the switch. ***Lead I will now have the largest P wave of all the limb leads***.

If the RA and LF electrodes are switched, 3 things will happen:

1. Leads aVR and aVF will switch places on the ECG.
2. Lead II will reverse its polarity 180° since its positive and negative poles have switched places.
3. Leads I and III will switch places because each lead is attached to an electrode involved in the switch.

I will discuss lead wire switches involving the right foot (ground) electrode in a future post.