A Series About Pauses – Part 1

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Music is based on the interaction of sound and silence. So is the rhythm of the heart. It is based on depolarizations and the pauses between them. We usually know when to expect the pauses – but sometimes they catch us off guard and create confusion. Let's look at some common, expected pauses first. Then I will introduce you to some unexpected pauses...

Compensatory and Non-compensatory Pauses

You might be surprised at the number of medical professionals who think they know all about compensatory pauses – but who actually know very little. Could you be one of those?

Here is a classic post-ectopic pause following a premature ventricular complex:

Figure 1

When we determine if a pause is compensatory or non-compensatory, we measure from P wave to P wave. Do NOT measure from R wave peak to R wave peak. There is a *reason* for not doing that which I will discuss later in this series! Whether a post-ectopic pause is *compensatory* or *non-compensatory* **depends on whether the SA node was reset or not**. It has NOTHING to do with the ventricles or with R waves! Yes... I am aware that there are examples all over the internet that show the pauses being measured from R wave to R wave. That's because the people writing those articles have no concept of the topic. They don't even understand what the post-ectopic pauses mean! There's a LOT of ECG misinformation on the internet – be very careful!

So, all we are looking for when we determine if a compensatory or a non-compensatory pause is present is this: ***was the SA node reset... or not?***

In Figure 1, the two arrows are equal in length. If this post-ectopic (PVC) pause were compensatory, the pause from the onset pf the P wave before the PVC to the onset of the first visible P wave after the PVC should be equal to **two *regular* P-P intervals**. Obviously, it is not! It is *non-compensatory*.

Here are the possibilities for this *non-compensatory pause*:

1. If the post-ectopic pause is only slightly less than two normal P-P intervals, consider the possibility that the patient has a significant sinus arrhythmia. In that case, the pause may actually be *compensatory*. From the rhythm strip in Figure 1, we see no evidence of sinus arrhythmia so that does *not* appear to be what's happening here.

2. When the ectopic beat reaches the SA node and resets it – which is the basis for all non-compensatory pauses – it may reset it to a membrane potential significantly *more negative than its usual level* (around -60 mV). This would require more time for the SA nodal pacemaker to reach threshold and discharge. Therefore, the post-ectopic pause could be extended *longer* than two P-P intervals. Remember: most non-compensatory post-ectopic pauses will be longer than one normal P-P interval but shorter than two normal P-P intervals. But whether shorter than two normal P-P intervals or longer… we still use the term non-compensatory.

3. The SA node is not a single cell. It is composed of thosands of myocytes with pacemaking capabilities. Sometimes, the retrograde ectopic impulse will cause the pacemaking function of the SA node to move to a *lower area of the node* with more parasympathetic input and thus a slower heart rate (longer cycle length). This could cause a slower rate following the ectopic beat which may slightly prolong the P-P interval. On the other hand, however, it *could* cause the pacemaking center to move to the *upper portion of the node* which has more sympathetic influence and the rate could increase, which would shorten the P-P interval. Actually, that is what has happened here! The P-P intervals are slightly shorter after the PVC, so the post-ectopic pause has occurred with a rate increase (shortening of the cycle length). (Here's a memory aid for the SA node: *Lower* is *Slower*!)

For completeness, here is a PVC with a *compensatory pause*:

Figure 2

Again, you see that I am measuring ***from P wave to P wave*** – *not* from R wave to R wave. R waves play NO ROLE in determining if a post-ectopic pause is compensatory or non-compensatory because ventricular depolarization is no longer involved once the PVC has appeared. With a compensatory pause, the SA node is unaffected and continues to discharge at its regular rate. NO P WAVE IS DROPPED! If you don't see a P wave, it's because it is hidden within the PVC or its repolarization abnormality. In Figure 2, we can see the sinus P wave quite clearly.

We say that the pause is *compensatory* because the pause between the non-conducted P wave and the P wave that ends the pause acts like a "place-holder," allowing the same time that it would have taken had the P wave conducted and produced a QRS. It is not shortened because of a lack of a QRS. Thus, it is ***compensatory***.

Compensatory pauses mean that the retrograde impulse ***did not enter the atria***. Generally, if there is a retrograde P wave we *assume* that the SA node was entered and reset. That may *not* be true in every case – but it usually is. How will you know? Well, is the pause compensatory or non-compensatory?

All this leads to the most important concept in today's post, which I have already introduced – **non-compensatory pauses**. Learning about non-compensatory pauses is like learning the multiplication tables in elementary school. You don't learn the multiplication tables so you can sit around reciting them to each other. You learn them for their use in other mathematical processes. The same with non-compensatory pauses. A non-compensatory pause following a PVC, PJC or PAC is an introductory concept. But as more advanced ECG nerds, we are more concerned with non-compensatory pauses that affect an ectopic focus. What if you can't see the ectopic beat that resulted in the non-compensatory pause? When I teach you about PVCs with non-compensatory pauses, I'm just introducing you to the concept of a pacemaker reset and and the effect it can have on more complex dysrhythmias.

More about that in the next installment: "A Series About Pauses – Part 2."

Here's a **PEARL** for those of you *deeper thinkers*…

You will see the terms **membrane potential** and ***resting* membrane potential** used throughout this series. Only working myocytes have resting membrane potentials. Phase 4 of the action potential of a working myocyte (the T-Q segment) is *stable*, which means it is flat – there is *no net current*. Nodal pacemaking cells and accessory pacemaking cells do *not* have a stable Phase 4. There is *always a slow, spontaneous depolarization* occurring during Phase 4. Therefore, those cells are *never* at rest: if they aren't producing an action potential then they are in the process of slowly depolarizing. But they are never *resting*.