Delays and Blocks Involving the Bundle Branches

Part 4 – *The Fascicles of the Left Bundle Branch*

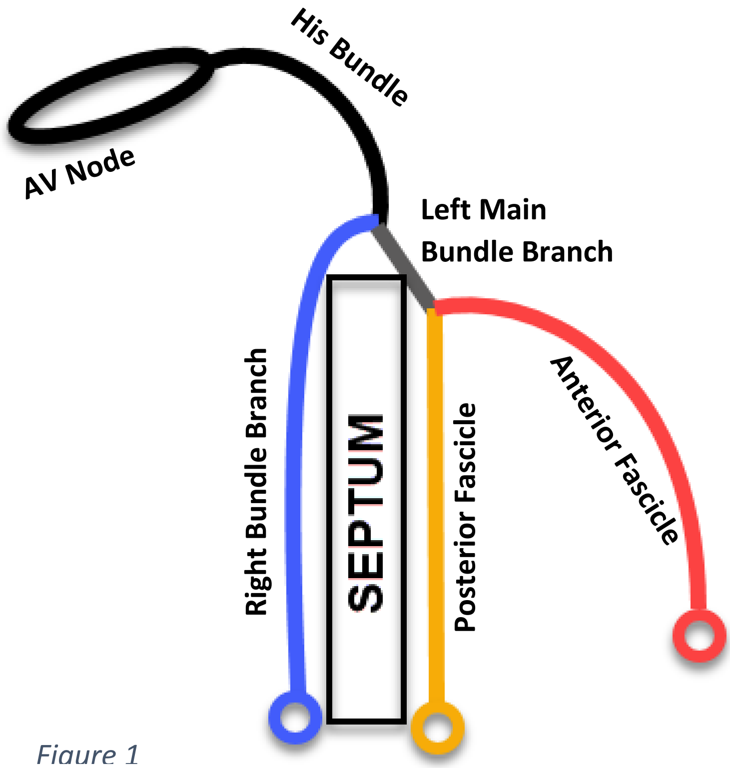

Figure 1

Welcome to the fourth and last installment of my series on *Delays and Blocks Involving the Bundle Branches*. In this installment, I'm going to teach you what you should know about the fascicles of the left bundle branch. While it is now thought that there are, in fact, *three* fascicles, we are only going to consider two of them. The three fascicles are the ***anterior fascicle***, the ***posterior fascicle,*** and the ***septal fascicle***. The anterior and posterior fascicles are present in everyone, while the septal fascicle may be present in only about 60% of people. I will be discussing the *anterior and posterior fascicles* in this installment. Unless you are an electrophysiologist, you needn't concern yourself about the septal fascicle. The concept of TWO fascicles works just fine!

Look at the schematic diagram of the *His Bundle – Bundle Branch – Fascicular* fibers in Figure 1. This is a very conceptualized diagram. The anterior and posterior fascicles actually look more like dense spiderwebs with a number of fibers from one fascicle intermingling with the fibers from the other fascicle. In reality… it's a real mess! But not to worry – you'll do just fine keeping this diagram in mind!

As you see, the His bundle divides into the *right bundle branch* and the *left main bundle branch* (also called the *left common bundle branch*). The right bundle branch continues down the interventricular septum traveling just beneath the surface of the right side of the septum – fairly superficially. The left main bundle branch is usually quite short – just a centimeter or two – and immediately divides into the anterior and posterior fascicle. At times, you may see the right bundle branch and the left main bundle branch referred to as *fascicles*, also. They are *all* fascicles, but I use the term *fascicle* only in reference to the *anterior* and *posterior fascicles*.

You have surely noticed the small circles at the ends of the right bundle branch and both fascicles: each of those circles represents the base of a major papillary muscle. In fact, all three fascicles are traveling directly to the base of their respective papillary muscle.

Before we go any further, do you know what a papillary muscle does? Although many have heard of papillary muscles, they often have the wrong idea about them. Some get their knowledge of anatomy and physiology mixed up. They see the papillary muscles and the strings arising from them that are attached to the valve leaflets (chordae tendinae) and they get the idea that the papillary muscles contract and open the AV valves (tricuspid and mitral valves), letting atrial blood enter their respective ventricles.

That is SO wrong! The papillary muscles contract to keep the AV valves closed! How does that happen? Well, consider the fact that just a few milliseconds after arriving in the ventricles via the bundle branches, the depolarization impulse is going to precipitate ventricular contraction which will exert a tremendous amount of pressure against the tricuspid and mitral valves. That pressure would be more than enough to cause the valves to completely evert back into the atria and allow a large amount of blood to be ejected back into them. So, the contraction of the papillary muscles is to provide *countertraction against the pressure* and keep the valves closed. The base of the anterior and posterior papillary muscles in the left ventricle play a role in some of the effects caused by the fascicles.

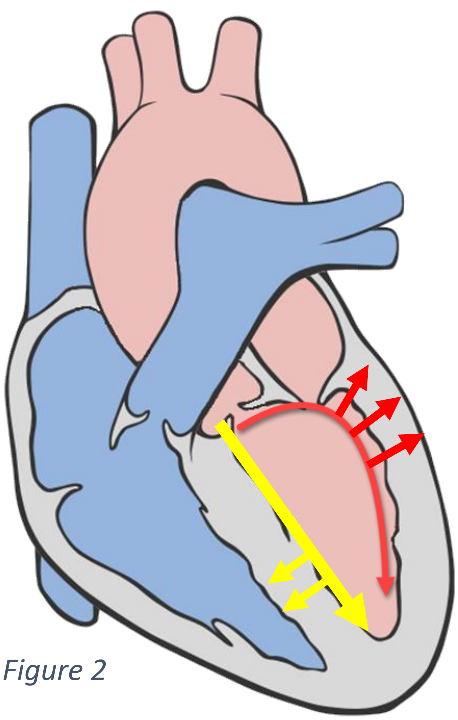

Figure 2

In Figure 2, we see the depolarization impulse traveling down the anterior fascicle (curving red arrow) to the base of the anterior papillary muscle. Remember: the anterior fascicle is like a web that fans out over the anterior and lateral surfaces of the left ventricle. We also see the impulse traveling down the posterior fascicle (wide yellow arrow) to the base of the posterior papillary muscle.

Let's look at the posterior fascicle for a moment. If I were to ask you, "In which direction will the ECG machine record the depolarization vector being transmitted by the posterior fascicle?", what would you answer? Most of my students would probably say that the vector is pointing directly toward the apex – *and they would be wrong!*

The ECG machine cannot record impulses traveling in conducting fibers. The voltage is *too small* and the impulse travels *too fast*. The machine only records vectors of impulses that are *traveling through muscle – through myocardium**. As the impulse travels down the posterior fascicle, it begins to excite the muscular septum just past the half-way point to the apex. In order to activate the septal myocardium, in which direction must the impulse travel? It must travel *down* and *to the right* (and also *anteriorly*)!

*Granted, the conducting fibers *are* myocardium, but their mass is extremely small.

As for the anterior fascicle, the impulse traveling down it to the base of the anterior papillary muscle will be activating myocardium from the base to the apex. And in which direction does that vector point? *Up* and *to the left* (and also *posteriorly*)!

In order to determine in which direction a cardiac vector is pointing – you must think about which part of the *myocardium* is being activated. Conducting fibers are often traveling perpendicularly to the depolarization vector.

OK… so, what is the concern about the papillary muscles? The papillary muscles must begin their contraction *before* the left ventricle in order to prevent regurgitation back into the atrium. Under normal circumstances, when the left ventricle contracts, it will do so very quickly and with great force. Also, the short distance between the two papillary muscles of the mitral valve will be a factor when we get to fascicular block.

So, what *does* the depolarization of the anterior and posterior fascicles look like on the 12-lead ECG? With one fascicle depolarizing the anterior and lateral walls and the other depolarizing the septum and inferior wall – that's a large amount myocardium. In fact, it's the entire left ventricle! The depolarizations on the ECG must be phenomenal! Well, if everything is happening *normally* – you won't see anything! Think for a moment: there is a large impulse traveling *down*, *to the right* and *anteriorly* and another large impulse traveling *up*, *to the left* and *posteriorly*. And these two forces are occurring *simultaneously*! The two vectors will *cancel each other* on the ECG. Now, let's be sure you understand this: the actual depolarization forces themselves are not cancelled – *just their representation on the 12-lead ECG*. We call this "cancellation of forces," but that is not exactly correct – *it's just the forces as displayed on paper or on a monitor that appear cancelled*. Again, both forces (vectors) are *real*, they are *present*, and they are *doing their job* – you just can't see it on the 12-lead ECG.

That is… you just can't see it, unless…

…one of the fascicles is blocked or suffers a significant delay in conduction. It will then depolarize *after* the other fascicle. Because there is no longer a cancellation of forces, you can see its effect on the 12-lead ECG because its vector will be printed last! This is where the topic gets really interesting! Even if one fascicle is blocked, they both eventually complete the depolarization of the left ventricle. Here's a very important pearl for you…

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*Just because a conducting pathway is blocked in the **antegrade** direction (the normal direction) does **not** necessarily imply that it is blocked in the **retrograde** direction. In fact, it usually isn't! So, if the anterior fascicle is blocked in the antegrade direction, the posterior fascicle will cause it to be depolarized from its distal end to its proximal origin **in retrograde fashion**.*

Let's see what this looks like…

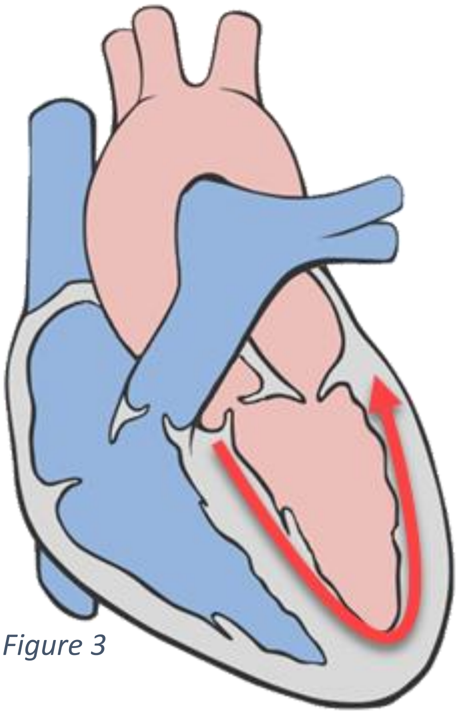

Figure 3

If the *anterior fascicle* is blocked in the *antegrade* direction, the impulse will…

1. travel down the posterior fascicle *as it normally does*…

2. excite the posterior papillary muscle…

3. travel the short distance from the base of the posterior papillary muscle to the base of the anterior papillary muscle via *cell-to-cell conduction* (there are no conducting fibers between the two papillary muscles), taking about 10 – 20 msec to do so…

4. enter the distal end of the anterior fascicular fibers located all around the base of the anterior papillary muscle…

5. travel up the anterior fascicle in the retrograde direction (i.e., "backwards") and excite myocardium all along the way.

In Figure 3, we can see this happening. The same thing can happen if the posterior fascicle is blocked (but depolarization will occur in the *reverse* direction)…

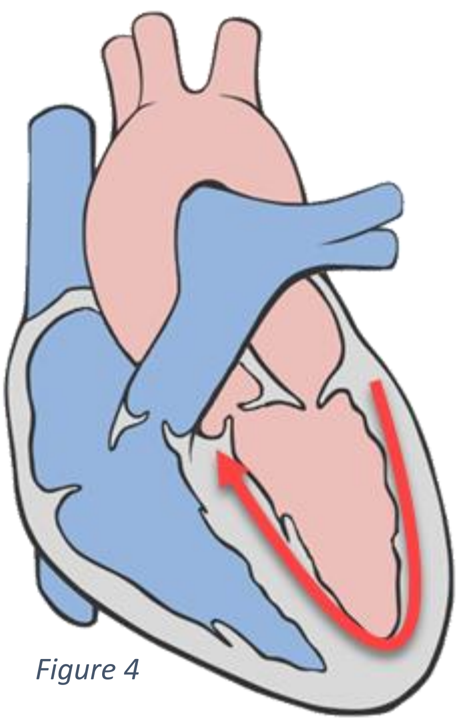

Figure 4

In Figure 4, you can see the direction of the impulse that would occur if the posterior fascicle were blocked. If the *posterior fascicle* is blocked in the *antegrade* direction, the impulse will…

1. travel down the anterior fascicle *as it normally does*…

2. excite the anterior papillary muscle…

3. travel the short distance from the base of the anterior papillary muscle to the base of the posterior papillary muscle via *cell-to-cell conduction* (there are no conducting fibers between the two papillary muscles) taking about 10 – 20 msec to do so…

4. enter the distal end of the posterior fascicular fibers located all around the base of the posterior papillary muscle…

5. travel up the posterior fascicle in the retrograde direction (i.e., "backwards") and excite myocardium all along the way.

So, what does this look like on the 12-lead ECG?

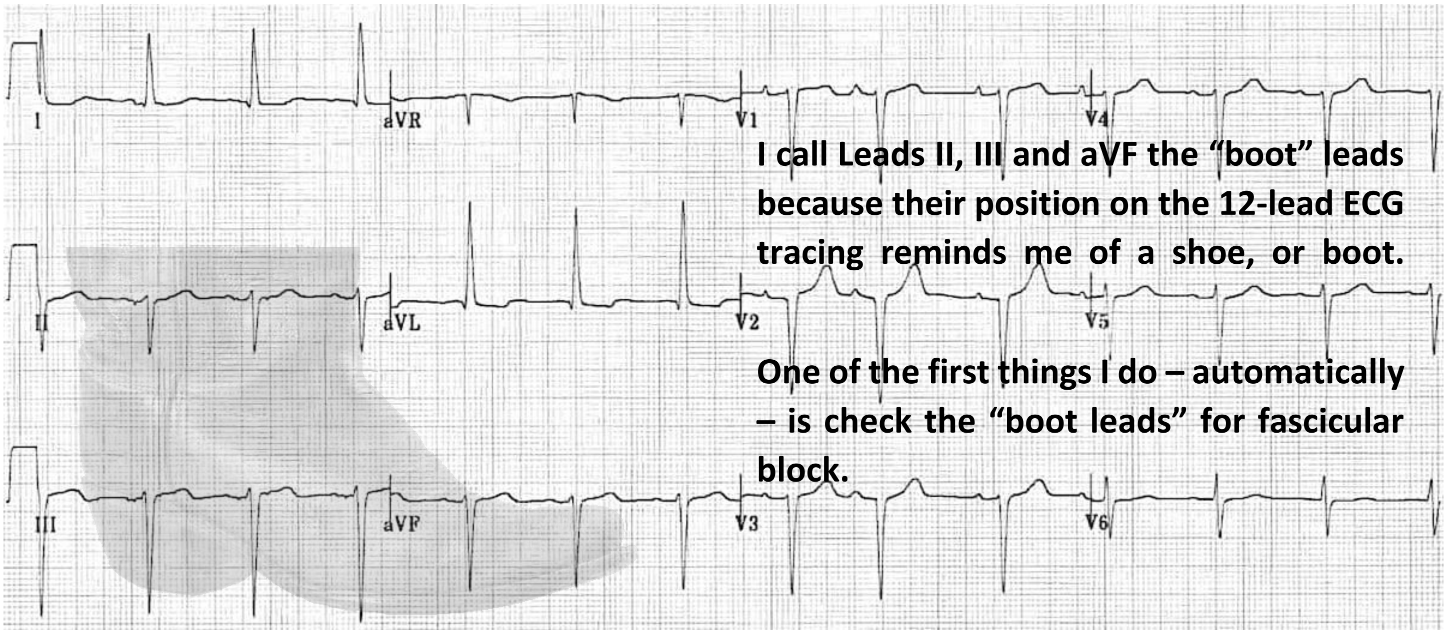

Figure 5

This is what an anterior fascicular block looks like on the 12-lead ECG (Figure 5). There are *three classic signs* – though *all* may not be present…

1. **rS complexes in the inferior leads (II, III and aVF).** This is absolutely required!

2. **qR complexes in the frontal plane lateral leads (I, aVL).** You may not *always* see this.

3. **Tall R wave in Lead aVL.** This is usually there, but may be attenuated by a cRBBB.

4. **cRBBB.** This is usually present, but it is *not required* for an anterior fascicular block. The *anterior fascicle* and the *right bundle branch* share the same blood supply.

PEARL!

You may have heard – or perhaps you have been using – the term "hemiblock." That was the original name for fascicular blocks. That is old and out-of-date now. There was also another older term for fascicular blocks that you may come across in the literature – "divisional blocks." That, too, is now archaic. Today everyone that is keeping up with new discoveries in the field of electrocardiography use the term "fascicular block." And you don't have to include the word "left," as in "left anterior fascicular block" since there are no fascicles in the right ventricle!

One of the things I always tell my advanced ECG interpretation students to do is to verify that Leads I and V6 look very similar because their positive poles are basically in the same place. What do you think of those two leads on the ECG in Figure 5? *They don't look anything like each* *other!* In fact, the transition lead has not even been reached by Lead V6 – it's probably somewhere around Lead V7 or V8! *Anterior fascicular block is one of the main causes of disparity between Lead I and Lead V6!*

An anterior fascicular block usually results in a rather *profound left axis deviation*. It is generally accepted that if the mean QRS axis (ÂQRS) in the frontal plane is more positive than -45°, an anterior fascicular block is not present. Granted, there may be rare exceptions, but as far as YOU should be concerned, it must be -45° or beyond (and sometimes it is *far beyond*). By the way, I use -45° as a requirement myself. Here's another pearl…

> *A left axis deviation always shifts the transition zone in the precordial leads to the LEFT (towards V6). Small degrees of left axis deviation may not be noticeable on the 12-lead ECG, but larger amounts usually are!*

The ECG in Figure 5 shows a classic anterior fascicular block (without cRBBB) with deep thin S waves in the inferior leads. When a cRBBB is present, the tall R wave in Lead aVL is sometimes shortened – *though not always!*

As you can see, the QRS complexes in the ECG (Figure 5) are very narrow – in fact, the QRS duration is quite normal. Impulse transmission through the fascicles is very fast – both antegrade and retrograde. Essentially the only time added is the 10 – 20 msec that it takes to travel between papillary muscle bases. Since many adults have QRS durations of around 80 msec, another 10 msec added to it is *still normal!* Of course, the QRS will be wider when cRBBB is present.

OK… but what does posterior fascicular block look like? Posterior fascicular blocks are very rare. If you are a primary care provider and do not see many ECGs, you could go your entire career without seeing one. But… if you DO see one, you had better be able to recognize it! Don't worry… it's not difficult! I have a collection of about 3,000 ECGs and I have only two ECGs with posterior fascicular block.

Before we look at a posterior fascicular block, let's talk a bit about the anatomy of these two fascicles (remember: we need not discuss the third – *septal* – fascicle)…

The *posterior fascicle* is about *three times thicker* than the anterior fascicle. In fact, some consider it to be the continuation of the left main bundle branch with the anterior fascicle being a small branch off it. The posterior fascicle *travels along the bottom of the septum*, safe from the turbulent left ventricular blood flow during systole. It also has *two blood supplies*.

The *anterior fascicle*, on the other hand, is *thin*, has a *single blood supply*, and must *cross the turbulent outflow tract of the left ventricle*. It is easy to see why posterior fascicular blocks are so rare and anterior fascicular blocks are relatively common.

OK… here is that ECG with a *posterior fascicular block*…

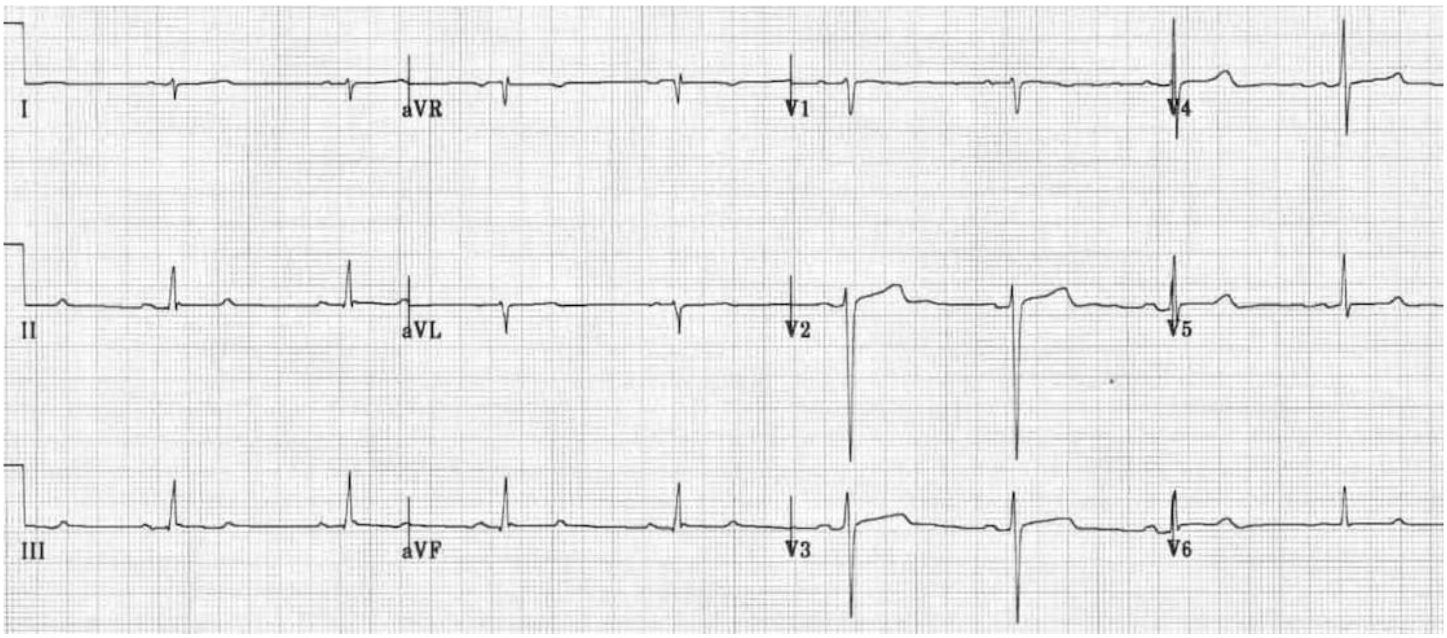

Figure 6

As you can see, it is mostly just the *opposite* of an anterior fascicular block…

1. **qR complex in the inferior leads (II, III and aVF).** This is absolutely required.

2. **rS complex in Leads I and aVL.** There must be a right axis deviation and that requires a negative QRS complex in Lead I.

3. **Right axis deviation.** Always present – by definition – due to the negative QRS in Lead I.

Posterior fascicular block usually presents with a cRBBB although, obviously, it can present without it. The ECG above (Figure 6) would be considered *extremely* rare!

If a posterior fascicular block is so rare, then why must you be able to recognize it? Due to its *thickness*, its *secure location*, and its *dual blood supply*, it takes a lot to damage the posterior fascicle. If it develops a block, you should *strongly* suspect that there is major damage to the myocardium and conducting system. You should always look for a posterior fascicular block when *right axis deviation* is present. However, *posterior fascicular block is so rare that it is a diagnosis of exclusion*. Other causes of right axis deviation should be ruled out first.

I teach advanced ECG *interpretation* – yet we have only "read" this ECG. Obviously, one must be able to "read" an ECG *before* interpreting it – but ***it is the interpretation that is most important***. That gives us the information we need to manage the patient.

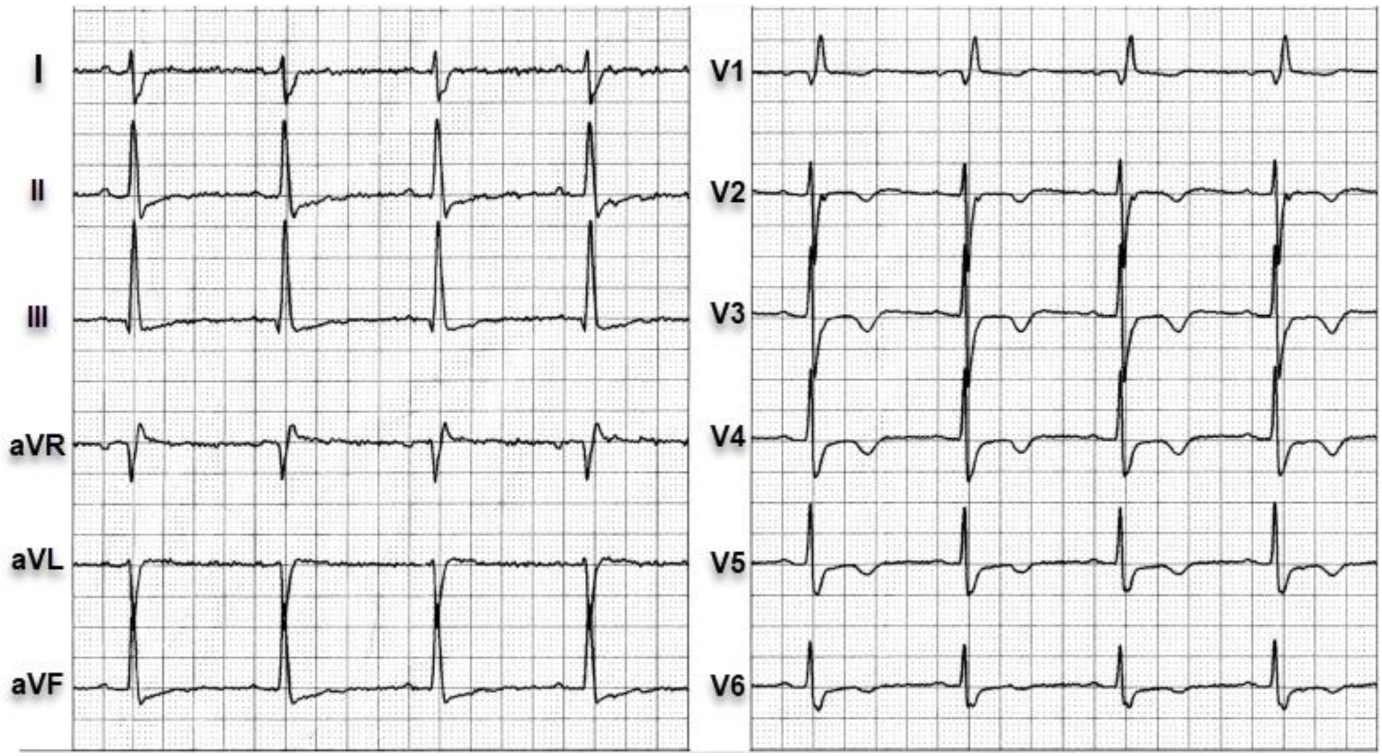

Figure 7 RBBB with Posterior Fascicular Block

Let's interpret the ECG in Figure 7. What do *you* see?

OK… here's what I see:

Under *normal* circumstances, there are only three pathways into the ventricles, the *right bundle branch*, the *anterior fascicle*, and the *posterior fascicle*. There is a cRBBB present, so the right bundle branch and the posterior fascicle have been eliminated in this ECG. That means that ***this patient's life depends on a single fascicle – the thin, easily-battered anterior fascicle***. That's bad! But it could be a lot worse. If there were a 1st degree AV block, *we would have to assume that the 1st degree block was not occurring in the AV node itself, but rather somewhere in the His – Purkinje system*. PR prolongation *usually* occurs in the AV node, but ***it can also occur in the bundle branches***. And what could cause that? *Disease – most likely ischemic heart disease*. So, what is the PR interval on this ECG? It is *normal!* That's *great!*

When you see that the heartbeat depends on just *one* fascicle – *and the PR interval is prolonged* – that is *usually a very bad sign!* While it is possible that the PR prolongation is occurring in the AV node (a relatively benign situation), *you had better assume that it is not!* Always assume, under these circumstances, that the 1st degree AV block is occurring *BELOW* the AV node. That implies that the slowing of conduction is occurring in the remaining functional fascicle; but it also implies that *the remaining fascicle is* ***very sick*** *and* ***likely to fail*** *– precipitating a* ***complete heart block*** *and* ***asystole****!* Otherwise, it would conduct at its normal speed and there would be no PR prolongation.

Well, this is the last installment of this series, "Delays and Blocks Involving the Bundle Branches." It seems like a lot of information during these last 4 weeks, but – *believe it or not!* – I have only scratched the surface of this topic.

Come join us and learn more about advanced ECG interpretation with me in the ***Advanced ECG Interpretation Boot Camp,*** the ***Masterclass in Advanced Electrocardiography*** or the ***Masterclass in Advanced Dysrhythmias***. And no – you do ***NOT*** have to already have advanced ECG interpretation skills! I will take you from *your level* to a much *higher level*. Feel more comfortable diagnosing very subtle MIs. Don't be intimidated by wide complex tachycardias. Confidently recognize when AV dissociation is due to 3rd degree AV block – and when it isn't!

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