Refractory Periods: Absolute/Relative and Effective/Functional

If you do any reading of the vast amount of literature regarding ECG interpretation, you have certainly encountered the terms **effective refractory period** and **functional refractory period**. In our introductory courses, we learn about the **absolute refractory period** and the **relative refractory period**, but no one ever teaches the effective and functional refractory periods. Most definitions are confusing and incomplete, so I have written a short monograph on this topic.

The **effective refractory period** is basically the same as the **absolute refractory period** – but there is a slight difference! The **absolute refractory period** is a *physiologic state* – it begins with the onset of the action potential at Phase 0 and ends at the point where an extra-strong stimulus is able to initiate a depolarization. Basically, it “ends where it ends.” It ends whether there is a stimulus present to challenge it or not.

Both the **effective and functional refractory periods** represent the electrophysiologist’s attempt to measure the **absolute refractory period** – **not the relative refractory period**. The absolute and relative refractory periods are real phenomena. They are also *observable* phenomena: we can see that an atrial impulse arrived during the absolute refractory period of the AV node or His bundle because it *failed to conduct in spite of more than adequate voltage*. We can see that an atrial impulse arrived during the relative refractory period of the AV node or His bundle because it conducted with a *prolonged PR interval*. But observing these phenomena doesn’t really tell us *exactly where* the absolute refractory period ends and the relative refractory period begins.

**The effective refractory period begins with a programmed stimulus (S1) and ends with a programmed stimulus (S2).** S1 marks the beginning of Phase 0 of the action potential and S2 marks the longest interval from S1 that fails to result in a depolarization.
The length of the effective refractory period depends on the strength of the stimulus being used and the length of the coupling interval (number of msec between S1 and S2). If the stimulus is not very strong, the effective refractory period will be measured well into the actual relative refractory period before a depolarization appears. If a stronger stimulus is used, a depolarization will be produced earlier and the effective refractory period will be shorter and more representative of the absolute refractory period. Also, if the coupling interval is rather long, the last non-conducted S2 may occur well before the end of the absolute refractory period. So it’s possible that the effective refractory period may actually be measured as being longer or shorter than the absolute refractory period. Although the effective refractory period and the absolute refractory period are not always exactly equal, for practical purposes they can be considered almost the same (since the electrophysiologist’s attempts to measure the effective refractory period are obviously much more precise than depicted in the diagram above). The terms are frequently used interchangeably in the literature but now you understand the subtle difference.

Many people make the mistake of thinking that if the effective refractory period is “basically” the same as the absolute refractory period, then the functional refractory period is the same as the relative refractory period. The functional refractory period and the relative refractory period are not at all the same, though they both relate to the point during the action potential in which an extra-strong stimulus can result in a depolarization. The functional refractory period is the electrophysiologist’s attempt to measure the distance from the onset of the action potential to the onset of the relative refractory period – not the duration of the relative refractory period! It actually represents the shortest interval between two consecutively conducted, paced impulses (S1 and S2). The relative refractory period begins at the point during repolarization that an exceptionally strong stimulus can initiate a depolarization and it ends (usually, but not always) with the onset of Phase 4. This is not what the functional refractory period measures!

The electrophysiologist, however, finds it more practical to measure from a programmed stimulus (S1) that initiates an action potential to the earliest point at which an (extra-strong) S2 is able to initiate a depolarization. Thus, the functional refractory period is a measurement between two programmed stimuli – S1 and S2 – and covers all the same territory as the effective refractory period. But again, this determination is voltage-dependent with the strength of the stimulus affecting where the first depolarization occurs.

But note that while the effective refractory period and the absolute refractory period are virtually the same, the functional refractory period and the relative refractory period are measurements of different sections of the action potential. What we think of as the relative refractory period begins near where the functional refractory period ends.
The functional refractory period includes all the absolute refractory period and typically some of the relative refractory period as well. The reason it may overlap both refractory periods is because the impulses generated by the pacing wire will appear at fixed intervals and that interval is statistically unlikely to appear exactly at the border between the two refractory periods. The longer the pacing cycle, the further into the relative refractory period the impulse measuring the functional refractory period will appear. Again the weaker the strength of the second stimulus (S2), the longer it will take before the stimulus is able to reach threshold during the relative refractory period. This will lengthen the functional refractory period. And, as you can see, lengthening the coupling interval between S1 and S2 can also have a significant effect on the length of the functional refractory period.

**Note:**

1. The effective refractory period is — by definition — shorter than the functional refractory period if the same stimulus strength and the same coupling intervals of S1 and S2 are used in both measurements.
2. The effective refractory period is (presumably) completely overlapped by the absolute refractory period while the functional refractory period and relative refractory periods overlap very little!
3. Both the effective refractory period and the functional refractory period begin and end with a programmed stimulus. The absolute refractory period and the relative refractory period are surmised based on the duration of the action potential (QT interval) and the response of the heart to the following sinus or ectopic impulse.
4. The effective refractory period essentially measures the end of the absolute refractory period while the functional refractory period measures the beginning of the relative refractory period.

The absolute refractory period ends around the time the membrane potential has returned to about -60°. Likewise, that is approximately where the relative refractory period begins.