1.3: Electrical Activity of the Heart and Basic Wave Forms on an EKG

Figure 1: Image 1, Nodes

Purple dot = Sinoatrial (SA) node

Green dot = Atrioventricular (AV) node

Blue lines: Bundle of His, purkinje fibers

Any part of the heart can act as the heart’s pacemaker (pacemaker in this context refers to the part of the heart in which depolarizations begin). The normal default pacemaker is the SA node because the SA node has the fastest resting pacemaker rate. If the SA node fails, any other portion of the heart can take over as the pacemaker. This can act as a fail-safe mechanism, as it means the SA node can malfunction and not cause immediate death.

Each portion of the heart has a different pacemaker rate. This means that, if a particular part of the heart becomes the default pacemaker instead of the SA node, it will typically set the resting rate at the following heart rates:

SA node: 60-100 BPM
Atria: 60-100 BPM

AV node: 40-60 BPM

Ventricles: 20-40 BPM

There are a variety of reasons the pacemaker of the heart may be different from the SA node, including irritability (defined above) and failure of higher nodes. The SA node is typically the default because it is the fastest - other nodes can take over and override the SA node if they contract more rapidly than the SA is going. This occurs with premature contractions (covered in the next section) and sometimes with other rhythms like ventricular tachycardia. Other areas of the heart like the atria, AV node, and ventricles can also take over as pacemaker in the event the SA node fails.

EKGs measure electrical activity in the heart. They do NOT measure actual movement, only the electrical impulses that cause muscle contractions. In a normal heart, the electrical impulse starts in the SA node, travels from there through the atria to the AV node. The electrical impulse is held there briefly, then is allowed to continue on through the bundle of His to the purkinje fibers into the ventricles.

Figure \((\PageIndex{2})\): Image 2, EKG

**P wave**: The electricity in the heart flowing from the SA node through the atria to the AV node; stimulates the atria to contract

**PR segment**: The pause in electrical activity when the AV node is holding the electrical impulse, allowing the ventricles to fill after the atria contract

**PR interval**: Measured from the beginning of the P wave to the beginning of the Q; should be 0.12 to 0.2 seconds (three small boxes to one big box)

**QRS complex**: Electricity in the heart flowing from the AV node down the bundle of His into the purkinje fibers; stimulates the ventricles to contract

**T wave**: The repolarization of the ventricles following contraction
**QT interval:** Measured from the beginning of the Q to the end of the T; should be about .45 seconds or less, can vary depending upon the overall heart rate. There is a formula that can be used to calculate an appropriate QT interval based on heart rate that will not be covered today.

**ST segment:** Measured from the end of the S to the beginning of the T

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**How do I sort out all this information?**

1. **EKG rate**

   Tachycardia – Rate >100

   Bradycardia – Rate <60

   Most EKG machines will automatically provide a rate provided they are set up correctly. EKG machines usually measure the QRS complex rate as the overall rate. The easiest alternative way to measure rate is to count the number of QRS complexes in a 6 second strip, then multiply that count by 10. There are other methods that are more precise in calculating the rate (which will be reviewed in a later chapter), but the focus of this overview of EKG interpretation is in clinically relevant interpretations. The difference between a rate of 70 and 77, for example, is of minimal clinical consequence in most settings.

   As noted above, “tachycardia” and “bradycardia” rates can vary somewhat depending upon where the electrical activity is originating from, but generally the terms refer to heart rates >100 or <60, respectively. Some patients do have a tachycardic or bradycardic rate at baseline.

2. **Is there a P wave for every QRS complex? Is there a QRS complex for every P wave?**

   The ratio of P waves to QRS complexes should be 1:1 in a normal rhythm (discussed in more detail in the next segment). Noting a P to QRS ratio that is different from a 1:1 ratio will help you discern certain rhythms.

3. **Do the P waves come at consistent intervals or “march out”? The QRS complexes?**

   “March out” means they all occur at consistent, regular intervals. It is most accurate to use a pair of calipers to measure this, but you can often see clearly when it does not march out in regular intervals, as with the irregular QRS complexes on this EKG:

   ![Image of EKG with irregular QRS complexes]

   **Figure \(\PageIndex{3}\): Image 3, March Out**

   P waves may be hidden underneath the larger QRS complexes, though this is generally a consideration primarily with particular types of heart blocks (covered in next section). P waves may also be entirely absent, which should be noted and will help you differentiate the rhythm.
4. Is the QRS complex wide or narrow?

A normal QRS complex is 0.12 seconds or less, which is referred to as a narrow complex. 3 of the small EKG boxes is equal to 0.12 seconds.

![QRS complex diagram](image)

A wide QRS complex is considered anything above 0.12 seconds. You may see certain rhythms referred to as “wide complex” or “narrow complex”; these terms refer to the width of the QRS complex and will help you distinguish certain rhythms. We will discuss what these types of QRS complexes mean with regards to physiology in another segment.

<table>
<thead>
<tr>
<th>Rate</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Rhythm</td>
<td></td>
</tr>
<tr>
<td>P waves</td>
<td></td>
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<tr>
<td>PR interval</td>
<td></td>
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<tr>
<td>QRS complex</td>
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<tr>
<td>ST segment</td>
<td></td>
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<tr>
<td>T waves</td>
<td></td>
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</tbody>
</table>

![Putting it all together diagram](image)

It is often helpful to have a diagram you use to measure and interpret each piece of the EKG to help you get into the habit of thinking about the parts. The above is one example of a diagram you may use that includes the most common information you will need to discern from an EKG tracing.

![Example diagram](image)

<table>
<thead>
<tr>
<th>Rate</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhythm</td>
<td>Regular</td>
</tr>
<tr>
<td>P waves</td>
<td>Upright, regular</td>
</tr>
<tr>
<td>PR interval</td>
<td>0.24 sec</td>
</tr>
<tr>
<td>QRS complex</td>
<td>0.12 sec</td>
</tr>
<tr>
<td>ST segment</td>
<td>0.44 sec</td>
</tr>
<tr>
<td>T waves</td>
<td>Upright</td>
</tr>
</tbody>
</table>

![Putting it all together (2) diagram](image)
In this example, the rate is measured at 60 as there are 6 QRS complexes in this 6 second strip. The rhythm is regular because the QRS complexes occur at regular intervals. The P waves are upright and occur at the same interval every time. The PR interval, QRS complex, and ST segments are 0.24 seconds, 0.12 seconds, and 0.44 seconds in duration. The T waves are upright. In a later segment, we will discuss how to apply this information to rule sets that determine what rhythm an EKG is considered to be.