**Chapter Outline**

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**Learning Outcomes**

- Summarize the process of evaluating ECG tracings and determining the presence of dysrhythmias.
- Identify the criteria used for classification of the dysrhythmias including rhythm, rate, P wave configuration, PR interval measurement, and QRS duration measurement.
- Describe the various rhythms and dysrhythmias including sinus, atrial, junctional, supraventricular, heart block, bundle branch block, ventricular, and pacemaker.
- Identify the dysrhythmias using the criteria for classification.
- Explain how each dysrhythmia may affect the patient.
- Discuss basic patient care and treatment for dysrhythmias.
- Describe an electronic pacemaker, its function, and the normal pacemaker rhythm characteristics.
- Identify the steps in evaluating electronic pacemaker function on an ECG tracing.

**Key Terms**

<table>
<thead>
<tr>
<th>Apnea</th>
<th>Bigeminy</th>
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<tr>
<td>Asystole</td>
<td>Biphasic</td>
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<tr>
<td>Atrial kick</td>
<td>Blocked or nonconducted impulse</td>
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<tr>
<td>Automaticity</td>
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<tr>
<td>bradycardia</td>
<td>neurological</td>
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<td>----------------------------</td>
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<tr>
<td>bundle branch block</td>
<td>oversensing</td>
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<td>capture</td>
<td>pacemaker competition</td>
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<tr>
<td>cardiac output parameters</td>
<td>pacemaker malfunctioning</td>
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<td>electronic pacemaker</td>
<td>palpitations</td>
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<td>focus (pl. foci)</td>
<td>quadgeminy</td>
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<tr>
<td>hypotension</td>
<td>supraventricular</td>
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<td>inhibited</td>
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<td>ischemia</td>
<td>tachycardia</td>
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<td>J point</td>
<td>trigeminy</td>
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<td>malsensing</td>
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### 5.1 Introduction

As discussed in Chapter 1, the ECG is an important tool used for the diagnosis and treatment of various cardiac and other related diseases. The recorded tracing of the ECG waveforms produced by the heart can tell you basic information about a patient’s condition. The ability to evaluate various ECG waveforms is an important skill for many health care professionals including nurses, doctors, and medical assistants. In addition, as a multiskilled health care employee you may be required to determine if an ECG is normal or abnormal and be able to respond to a cardiac emergency, if necessary. You will follow your scope of practice and the policy at your place of employment when evaluating and reporting dysrhythmias.

As you have already learned, the ECG waveform has various components such as waves, segments, and intervals that are evaluated and classified based on their size, length of time, and location on the tracing. All of these different components determine the type of cardiac rhythm. In order to evaluate a rhythm, you must first understand each component and its normal appearance. When these components differ from the expected norm, a dysrhythmia (or arrhythmia) is indicated. Remember, an abnormal ECG tracing may only be the result of artifact. The tracing must be evaluated for artifact prior to the evaluation of the heart rhythm.

The process of determining or labeling the type of cardiac dysrhythmia can be challenging. The best approach in determining the actual rhythm is to take on the role of a detective. Detectives will gather all the information they can before determining who is the suspect or how something has happened. The process of ECG analysis is similar. We first gather all the data regarding the different waveforms and their patterns. The next step is to match all the information to the specific ECG rhythm criteria in order to classify the various cardiac dysrhythmias.

In this chapter, you are introduced to the rhythm criteria used to identify the various cardiac dysrhythmias. You will learn the process of evaluating dysrhythmia, which will lay a strong foundation for your beginning practice or continued education in electrocardiography. Most importantly, after completing this chapter you should be able to recognize abnormalities in the cardiac rhythm and respond appropriately.
1. What is evaluated and classified when determining dysrhythmias?

5.2 Identifying the Components of the Rhythm

ECG analysis consists of a five-step process of gathering data about each rhythm strip. These steps include evaluating the following components of the ECG rhythm strips:

- Rhythm (regularity)
- Rate
- P wave configuration
- PR interval
- QRS duration and configuration

Once the information is gathered, the data are compared to the specific criteria for each dysrhythmia. Cardiac dysrhythmia interpretation is an art. Frequently, you will find practitioners discussing how to classify a dysrhythmia because patients may experience a variety of different cardiac dysrhythmias at the same time. This makes it difficult to determine the origin of the dysrhythmia or to classify it. The more interpretation you perform, the more efficient you become in classifying the rhythm.

Before you begin the steps, you should know that lead II is the most common monitoring lead. It is used in this chapter unless otherwise specified.

Step 1: Determining the ECG Rhythm or Regularity

Determining the rhythm involves evaluating the pattern of how the atria and ventricles contract. The rhythm can occur in regular or irregular intervals. Each chamber of the heart is assessed for its type of pattern. In Chapter 3, you learned that the P wave represents atrial contraction and the QRS complex represents ventricular contraction. The rhythm of atrial contraction is evaluated by assessing the regularity or irregularity of the occurrence of the P waves. The QRS complexes are assessed to evaluate ventricular contraction. Calipers are used for this portion of the analysis to measure the distance between the P waves and the width of the QRS complex (see Figure 5-1).

The P-P wave interval should be evaluated first. The caliper interval is established when the first point of the caliper is placed on the beginning of one P wave and the second point on the beginning of the next P wave. Measuring several of these intervals determines if the P waves are occurring in a regular sequence. At least 10 seconds of the ECG tracing of P waves are measured to determine if the P waves occur in a regular or irregular rhythm throughout the rhythm strip (see Figure 5-2).

Next, determine the rhythm of the QRS complex. Since the QRS complex is a configuration of three possible waveforms, it is important to analyze this interval from the same waveform in each of the QRS complexes. For
example, it is often easier to see the R wave of the QRS complex. Measuring the R-R wave interval is easy due to its upward deflection (see Figure 5-3). Occasionally, the QRS complex does not exhibit an R wave, in which case you can use the point of the Q and S wave junction as an easy point of evaluation. Most importantly, you must measure the same part of the waveform for each QRS complex to determine the regularity of the ventricular depolarization. The first point of the caliper should be placed on the first QRS complex and the other point placed on the next QRS complex. The interval should be evaluated throughout at least a 6-second strip to determine the rhythm of the QRS complexes.

**Step 2: Determining the Atrial and Ventricular Rate**

The method used to calculate the heart rate is based on whether the rhythm is regular or irregular. The heart rate must be determined for both atria and ventricles. The atrial rate is determined by the P-P wave interval measurements, and the ventricular rate is determined by the R-R wave measurement. Most frequently, the atrial and ventricular rates will be the same; sometimes, however, the rates may be different due to conditions occurring in the myocardium. It is important to note if the atrial rate is different from the ventricular rate since this will help narrow the selection of dysrhythmias. The methods used to differentiate the rates are described in the following sections.

**Regular Rhythm**

Once you have determined that the rhythm is regular, you can use this method to calculate the atrial and ventricular rate. The caliper interval of the P-P or R-R measurement is placed on the ECG paper to determine the number of small boxes or duration of time. (Remember from Chapter 3 that each small box is equal to 0.04 seconds.) Move the caliper interval to the top or the bottom of the page so that the number of boxes can be determined without interference from the ECG tracing. Once you have counted the small boxes,
divide the number into 1500 to calculate the heart rate. The ventricular rate is determined in the same manner except you will need to count the number of boxes between the QRS complexes. Table 5-1 provides the heart rates based on the number of small boxes between the two P or two R waves. This method of calculation provides an accurate heart rate similar to measuring a person's pulse, unlike the method described in Chapter 3, which provides only an estimate. The actual rate is extremely important when the heart rate is either tachycardia (more than 100 beats per minute) or bradycardia (less than 60 beats per minute).

**Irregular Rhythm**

When the rhythm is irregular, as determined in Step 1, the interval between the P waves or the QRS complexes is not constant. To determine the heart rate
for an irregular rhythm, use the 6-second method as described in Chapter 3. Simply multiply the number of P waves and QRS complexes in a 6-second strip by 10. This method is often used in emergencies to determine an estimated heart rate (pulse rate) for the patient.

**Step 3: Identifying the P Wave Configuration**

Analyzing P waves and their relationship with the QRS complex is necessary to determine the type of dysrhythmia. The P wave reflects the atrial contraction and how the electrical current is moving through the atria. The relationship between the P wave and QRS complex provides information regarding the coordination between atrial and ventricular contractions. Several questions need to be answered when analyzing the P wave.

- *Are the shapes and waveforms all the same?* If they appear to be different, the route in which the current is moving through the atria is not on the same pathway. Sometimes the P wave may not exist.
- *Does each P wave have a QRS complex following it?* In normal conduction pathways, the QRS complex always follows the P wave. If there are additional P waves or QRS complexes present without a P wave in front, the normal conduction pathway may not have been used and the atria and ventricles are not contracting together.

**Step 4: Measuring the PR Interval**

The PR interval measures the length of time it takes the electrical current to be initiated at the sinoatrial node and travel through the electrical current pathway to cause a ventricular contraction. The PR interval is determined by measuring from the beginning of the P wave, or its up slope, to the beginning of the QRS complex. This is the first indication of ventricular depolarization. Not all tracings will show a Q wave. In the absence of a Q wave, the second caliper tip is placed at the beginning of the R wave. (Please review Figure 5-3 for an example of computerized caliper measurement of the R-to-R wave interval.)
The normal range of the PR interval is 0.12 to 0.20 second (see Figure 5-4).

When determining the measurements, the time interval should always be in multiples of 0.02 second, which represents one-half of the smallest box. To effectively determine measurements to 0.01 second, the small box on the ECG paper would need to be divided into four smaller divisions. This can be done effectively only with a computer, not a practitioner's eyes.

### TABLE 5-1 Calculating Heart Rates with a Regular Rhythm

<table>
<thead>
<tr>
<th>Small Boxes in P-P or R-R Interval</th>
<th>Heart Rate</th>
<th>Small Boxes in P-P or R-R Interval</th>
<th>Heart Rate</th>
<th>Small Boxes in P-P or R-R Interval</th>
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<td>35</td>
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</tbody>
</table>

A rate calculator can also be used for regular rhythms. The start mark is placed at the first P wave or R wave, whichever you are using, where the next consecutive P or R wave lines up is the approximate heart rate. See the following figure.
Step 5: Measuring the QRS Duration and Analyzing the Configuration

Measuring the QRS complex is essential in determining the duration of time it takes for the ventricles to depolarize or contract. This information is helpful in discriminating between different dysrhythmias. If the QRS complex is narrow, or within the normal limits of 0.06 to 0.10 second, current has traveled through the normal ventricular conduction pathways to activate the ventricles to contract. When the QRS complex is wide, 0.12 second or greater, the current is taking longer than normal to contract the ventricles.

To measure the QRS duration and configuration, place the first caliper point where the QRS complex starts and the second point at the J point (see Figure 5-5). The J point is located where the S wave stops and the ST segment is initiated. It marks the point at which ventricular depolarization is completed and repolarization begins. It is important to carefully identify this
ending point of the QRS complex, since many times the ST segment may not be at the isoelectric line.

Several questions need to be answered when determining the QRS measurement and configuration (see Figure 5-6).

- Are all the QRS complexes of equal length?
- What is the actual measurement, and is it within the normal limits?
- Do all QRS complexes look alike, and are the unusual QRS complexes associated with an ectopic beat?

After you have completed these five steps of identifying the components of the rhythm, you will then compare the information to the specific criteria for classifying each of the dysrhythmias. The rest of this chapter explains the specific criteria for classification related to common rhythms and dysrhythmias that will help you identify the various ECG rhythms.

1. Name the five components that must be evaluating a rhythm strip.

2. A regular rhythm has 19 small boxes between the P-P interval. What is the heart rate?

3. After you measure the QRS duration and configuration, what other questions need to be answered?

Answer the preceding questions and complete the “Identifying the Components of the Rhythm” activity on the student CD under Chapter 5 before you proceed to the next section.
5.3 Rhythms Originating from the Sinus Node (Sinus Beat)

The sinoatrial node is the normal or “primary” pacemaker of the heart. It generates an electrical impulse that travels through the normal conduction pathway to cause the myocardium to depolarize. Electrical current starts at the sinoatrial node and travels the normal conduction pathway to the atrioventrical node and continues through the bundle of His and bundle branches to the ventricles. Because the rhythm starts at the sinoatrial node, it is called sinus rhythm. The electrical current is produced at the sinus node at a rate of 60 to 100 beats per minute. The rates of the rhythm will vary, and the types of sinus beats may include sinus rhythm, sinus bradycardia, sinus tachycardia, and sinus dysrhythmia.

Normal Sinus Rhythm

Sinus rhythm is reflective of a normally functioning conduction system. The electrical current is following the normal conduction pathway without interference from other bodily systems or disease processes (see Figure 5-7).

Criteria for Classification

- **Rhythm**: The intervals between the two P and two R waves will occur in a consistent pattern.
- **Rate**: Both the atrial and ventricular rate will be between 60 and 100 beats.
- **P wave configuration**: The P waves will have the same shape and are usually upright in deflection on the rhythm strip. A P wave will appear in front of every QRS complex.
- **PR interval**: The PR interval measurement will be between 0.12 and 0.20 second, which is within normal limits. Each PR interval will be the same, without any variations.
- **QRS duration and configuration**: The QRS duration and configuration measurement will be between 0.06 and 0.10 second, which is within normal limits. Each QRS duration and configuration will be without any variations from PQRST complex to complex.

What's Unique about Normal Sinus Rhythm?

Sinus rhythm is the only rhythm for which all five steps are within normal limits.

Figure 5-7  Normal Sinus rhythm.
Sinus rhythm is the desired rhythm. Patients with this rhythm should have normal cardiac output. Normal cardiac output means that the heart is beating adequately, pumping blood to the body's organs to maintain normal function. Signs and symptoms of adequate cardiac output include an alert and oriented patient with no difficulty breathing, no chest pain or pressure, and a stable blood pressure.

Because this is a normal rhythm, no intervention is necessary. If the patient's rhythm returns to sinus rhythm from another dysrhythmia, it is always important to make sure that the patient is not experiencing problems with low cardiac output, which indicates that the heart is not pumping adequately (see Table 5-2). Any time a patient displays symptoms of low cardiac output, a licensed practitioner needs to be informed for further assessment.

**TABLE 5-2 Signs and Symptoms of Decreased Cardiac Output**

Observe for any of these signs and symptoms associated with decreased cardiac output during ECG monitoring.

<table>
<thead>
<tr>
<th>Neurological</th>
<th>Cardiac</th>
<th>Respiratory</th>
<th>Urinary</th>
<th>Peripheral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in mental status</td>
<td>Chest pain</td>
<td>Difficulty breathing</td>
<td>Decreased urinary output of less than 30 cc in one hour</td>
<td>Hypotension</td>
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<tr>
<td>Light-headedness</td>
<td>Palpitation</td>
<td>Shortness of breath</td>
<td></td>
<td>Pale skin</td>
</tr>
<tr>
<td>Dizziness</td>
<td>Chest discomfort</td>
<td>Frothy sputum</td>
<td></td>
<td>Skin cool and clammy to the touch</td>
</tr>
<tr>
<td>Confusion</td>
<td>Enlarged cardiac size</td>
<td>Fluid present in lungs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>Congestive heart failure</td>
<td>Lung congestion</td>
<td></td>
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</tbody>
</table>

**How the Patient Is Affected and What You Should Know**

Sinus rhythm is the desired rhythm. Patients with this rhythm should have normal cardiac output. Normal cardiac output means that the heart is beating adequately, pumping blood to the body’s organs to maintain normal function. Signs and symptoms of adequate cardiac output include an alert and oriented patient with no difficulty breathing, no chest pain or pressure, and a stable blood pressure.

Because this is a normal rhythm, no intervention is necessary. If the patient’s rhythm returns to sinus rhythm from another dysrhythmia, it is always important to make sure that the patient is not experiencing problems with low cardiac output, which indicates that the heart is not pumping adequately (see Table 5-2). Any time a patient displays symptoms of low cardiac output, a licensed practitioner needs to be informed for further assessment.
conduction pathway. The only difference between this rhythm and sinus rhythm is that the rate is less than the normal inherent rate of the SA node.

**Criteria for Classification**

- **Rhythm:** The R-R interval and P-P interval will occur on a regular and constant basis.
- **Rate:** The atrial and ventricular rates will be equal and less than 60 beats per minute.
- **P wave configuration:** The shapes of each of the P waves are identical. There is a P wave in front of each of the QRS complexes. No additional P waves or QRS complexes are noted.
- **PR interval:** The PR interval measurement will be between 0.12 and 0.20 second, which is within normal limits. Each PR interval will be the same.
- **QRS duration and configuration:** The QRS duration and configuration measurement will be between 0.06 and 0.10 second, which is within normal limits. Each QRS duration and configuration will be the same, without any variations from QRS complex to complex.

**What’s Unique about Sinus Bradycardia?**

For sinus bradycardia, the heart rate is less than 60 and all other measurements are within normal limits.

**How the Patient Is Affected and What You Should Know**

The patient who exhibits sinus bradycardia may or may not experience signs and symptoms of low cardiac output. When administering an ECG to a patient with a slow heart rate, it is important to observe for the symptoms of low cardiac output (see Table 5-2). Remember, though the patient may look all right, he or she can quickly experience difficulties with low cardiac output. When you observe symptoms of low cardiac output, report any findings to a licensed practitioner immediately. This rhythm may require drug administration or application of a pacemaker.

**Sinus Tachycardia**

Sinus tachycardia is a condition in which the sinoatrial node fires and the electrical impulse travels through the normal conduction pathway but the rate of impulse firing is faster than 100 beats per minute (see Figure 5-9).
Criteria for Classification

- **Rhythm:** The R-R interval and P-P interval will be equal and constant.
- **Rate:** Both the atrial and ventricular rates will be the same, between 100 and 150 beats per minute.
- **P wave configuration:** The P waves will have the same shape and usually are upright in deflection on the rhythm strip. There will be a P wave in front of every QRS complex.
- **PR interval:** The PR interval measurement will be between 0.12 and 0.20 second. This is within normal limits. Each PR interval will be the same, without any variations.
- **QRS duration and configuration:** The QRS duration and configuration measurement will be between 0.06 and 0.10 second, which is within normal limits. Each QRS duration and configuration will be the same, without any variations from QRS complex to complex.

What’s Unique about Sinus Tachycardia?

For sinus tachycardia, the heart rate is greater than 100 and all other measurements are within normal limits.

How the Patient Is Affected and What You Should Know

The effect of this rhythm on the patient depends on the rate of tachycardia above the patient’s normal resting heart rate. For example, if the patient’s normal resting heart rate is 90 and now the patient is exhibiting a rate of 108 beats per minute after walking the hallway, the tachycardia would be expected and is viewed as the patient’s normal response to exercise. However, if the patient’s normal heart rate is 60 and it is now 140, the patient is probably experiencing symptoms of low cardiac output. Often the patient will complain of **palpitations** or “heart fluttering” with faster rates. If the patient has had a recent myocardial infarction, sinus tachycardia is considered to be more serious or even life threatening.

When caring for a patient who is experiencing sinus tachycardia, first observe for signs and symptoms of low cardiac output. If evidence of low cardiac output is observed, a licensed practitioner should be notified immediately. Medication may need to be administered by a licensed practitioner.
Sinus Dysrhythmia

Sinus dysrhythmia is a condition in which the heart rate remains within normal limits but is influenced by the respiratory cycle and variations of vagal tone (a condition in which impulses over the vagus nerve cause a decrease in heart rate), causing the rhythm to be irregular. For instance, when a patient inhales air, the pressure inside the chest cavity increases, causing pressure on the heart, specifically the sinoatrial node. The heart rate will slow with this increase in pressure. As the patient exhales, the chest cavity pressure decreases, allowing the SA node to fire more easily. Therefore, the heart rate will increase during exhalation (see Figure 5-10).

Criteria for Classification

- **Rhythm:** The interval between the P-P and R-R waves will occur at irregular periods.
- **Rate:** Both the atrial and ventricular rates will be the same, between 60 and 100 beats per minute.
- **P wave configuration:** The P waves will have the same shape and usually are upright in deflection on the rhythm strip. There will be a P wave in front of every QRS complex.
- **PR interval:** The PR interval measurement will be between 0.12 and 0.20 second. Each PR interval will be the same, without any variations.
- **QRS duration and configuration:** The QRS duration and configuration measurement will be between 0.06 and 0.10 second. Each QRS duration and configuration will be the same, without any variations from QRS complex to complex.

What’s Unique about Sinus Dysrhythmia?

For sinus dysrhythmia, the P-P and R-R intervals will progressively widen then narrow following the patient’s breathing pattern.

How the Patient Is Affected and What You Should Know

Patients usually show no clinical signs or symptoms with sinus dysrhythmia. If the irregularity is severe enough to decrease the heart rate to the 40s, the patient may complain of palpitations or dizziness. This depends on how slow the heart beats when the SA node is suppressed from the respiratory
or vagal influences. You should notify the physician or other licensed practitioner when the heart rate slows below 50 or the patient complains of dizziness or palpitations. A copy of the rhythm strip should be mounted on the patient’s medical record for documentation.

**Sinus Arrest**

Sinus arrest occurs when the SA node stops firing, causing a pause in electrical activity. During the pause, no electrical impulse is initiated or sent through the normal conduction system to cause either an atrial or aventricular contraction (see Figure 5-11).

**Criteria for Classification**

- **Rhythm:** The interval between the P-P and R-R waves will occur at irregular periods.
- **Rate:** Both the atrial and ventricular rates will be the same. The rate will vary depending on the amount of electrical activity occurring from the sinoatrial node.
- **P wave configuration:** The P waves will have the same shape and usually are upright in deflection on the rhythm strip. There will be a P wave in front of every QRS complex.
- **PR interval:** The PR interval measurement will be between 0.12 and 0.20 second, which is within normal limits. Each PR interval will be the same, without any variations.
- **QRS duration and configuration:** The QRS duration and configuration measurement will be between 0.06 and 0.10 second, which is within normal limits. Each QRS duration and configuration will be the same, without any variations from QRS complex to complex.
- **Length of pause:** The length of pause needs to be measured to determine how long the heart had no rhythm. To measure, place the calipers on the R-R interval around the pause. Once the time frame is determined, calculate the length of time for the pause by multiplying the number of boxes by 0.04 second. The frequency of pauses is also noted because the more frequent the pauses, the more urgent the situation.

It should be noted that the arrest period may be terminate by an escaped beat from one of the subsidiary pacemakers when the heart rate is less than 60 beats per minute. In this instance, there would be a junctional or ventricular escape beat then resumption of the usual electrical activity.
What Unique about Sinus Arrest?

During sinus arrest, complete cardiac complexes precede and follow the arrest period. There are no nonconducted QRS complexes and no isolated P waves.

How the Patient Is Affected and What You Should Know

The seriousness of sinus arrest depends on the length of the pause. The patient will experience signs and symptoms of decreased cardiac output if the pause is 2 seconds long and occurs on a frequent basis. The pauses may also cause periods of ischemia (when cells are deprived of oxygen), hypotension, dizziness, and syncope (loss of consciousness).

The patient may initially appear to be asymptomatic (without symptoms) and then develop signs and symptoms of low cardiac output. Therefore, it is important to observe the patient frequently for signs of low cardiac output. Notify a licensed practitioner of these symptoms and provide information about the frequency and length of pauses. The patient will require immediate treatment.

Checkpoint Questions

1. What rhythm originating in the sinus node is considered “normal”?

2. What two rhythms originating in the sinus node only affect the heart rate and how is it affected?

3. What rhythm originating in the sinus node is affected by the breathing pattern?

Answer the preceding questions and complete the “Rhythms Originating from the Sinus Node (Sinus Beat)” activity on the student CD under Chapter 5 before you proceed to the next section.

5.4 Rhythms Originating from the Atria

Atrial dysrhythmia is caused by an ectopic beat in either the right or the left atria. However, the atrial origin is outside the SA node, which interrupts the inherent rate of the SA node. The heart works on the principle that the fastest impulse will control the heart rate. Since the atrial ectopic beat is generating electrical impulses faster than the sinoatrial node, the ectopic beat will over-ride the sinoatrial node impulse and cause the atria and ventricles to depolarize. Dysrhythmias that are caused by the atrial ectopic site include premature atrial complexes, atrial tachycardia, atrial flutter, and atrial fibrillation.
Sinus Arrest

A patient is in sinus arrest that lasts longer than 6 seconds. This indicates that no electrical current is traveling through the cardiac conduction system and is known as \textit{asystole}. What should you do?

Atrial dysrhythmias occur from conditions that cause pressure on the atria such as damage to the atria from myocardial infarction, valvular problems, or neurological influences (pertaining to the nervous system). When the area is stressed or damaged, the cells become unstable and the electrical state may cause depolarization to occur more easily.

Premature Atrial Complexes

Premature atrial complexes (PACs) are electrical impulses that originate in the atria and initiate an early impulse that interrupts the inherent regular rhythm (see Figure 5-12).

Criteria for Classification

- \textit{Rhythm}: The regularity between the P-P interval and R-R interval is constant with the exception of the early complexes. There will be a section of the rhythm that is regular and occasionally an early complex.
- \textit{Rate}: The rates of the atria and ventricles will usually be within normal limits of 60 to 100, depending on the frequency of the PACs.
- \textit{P wave configuration}: The P waves will have the same configuration and shape. The early beat will have a different shape than the rest of the P waves on the strip. This P wave may be flattened, notched, \textit{biphasic} (have two phases), or otherwise unusual. It may even be hidden within the T wave of the preceding complex. Evidence that the P wave is hidden within the T wave includes a notch in the T wave, a pointed shape, or being taller than the other T waves.
- \textit{PR interval}: The PR interval will measure within normal limits of 0.12 to 0.20 second. The early beat will probably have a different PR measurement than the normal complexes but will be within normal limits.
- \textit{QRS duration and configuration}: The QRS duration and configuration will be within normal limits of 0.06 to 0.10 second.

\textbf{Figure 5-12} Premature atrial contraction.
What’s Unique about Premature Atrial Complexes?

A premature atrial complex is a beat earlier than it should be with a positively deflected P wave.

Determine the underlying rhythm of sinus rhythm, sinus bradycardia, sinus tachycardia, or sinus dysrhythmia when identifying PACs. The rhythm strip must be labeled with this underlying rhythm and the type of PAC. An example of this terminology is “sinus rhythm with trigeminal PACs” (trigeminy refers to a pattern in which every third complex is a premature beat).

How the Patient Is Affected and What You Should Know

With each PAC, the atria do not achieve the maximum blood capacity prior to contraction. This lack of blood causes a decrease in cardiac output and less volume in the ventricles prior to ventricular contraction. Therefore, in the patient who has prior cardiac disease, frequent PACs can cause the patient to experience symptoms of low cardiac output.

When caring for a patient with PACs, observe the patient for signs and symptoms of low cardiac output. Monitoring the amount or frequency of PACs is essential. The patient may complain of palpitations from the early beats. The severity of the patient’s complaints is related to the frequency of the PACs. In addition, frequent PACs may indicate that a more serious atrial dysrhythmia may follow. The more frequent occurrence indicates that the ectopic focus (cardiac cell that functions as an ectopic beat) may continue and take control of the heart rate. Any observation of low cardiac output should be communicated to a licensed practitioner for appropriate treatment.

Wandering Atrial Pacemaker

Wandering atrial pacemaker (WAP) is a rhythm in which the pacemaker site shifts between the SA node, atria, and/or the AV junction. The P wave configuration changes in appearance during the pacemaker shift. At least three different P wave configurations in the same lead indicate a wandering atrial pacemaker (see Figure 5-13).

Figure 5-13  Wandering atrial pacemaker.
Criteria for Classification
- **Rhythm:** Slightly irregular
- **Rate:** Should be within normal limits of 60 to 100 beats per minute
- **P wave configuration:** Continuous change in appearance
- **PR interval:** Varies
- **QRS duration and configuration:** Usually within normal limits

What’s Unique about Wandering Atrial Pacemaker Rhythm?
WAP has a changing P wave configuration with at least three variations in one lead. The rhythm may be irregular.

How the Patient Is Affected and What You Should Know
WAP is a normal finding in children, older adults, and well-conditioned athletes and does not usually cause clinical signs and symptoms. However, it may also be related to some types of organic heart disease and drug toxicity.

Multifocal Atrial Tachycardia
Multifocal atrial tachycardia (MAT) has a P wave that changes from beat to beat and a heart rate of 120 to 150 (see Figure 5-14). It has the same characteristics as wandering atrial pacemaker (WAP) and is frequently mistaken for atrial fibrillation. It can be distinguished by looking closely for visible changing P waves.

Criteria for Classification
- **Rhythm:** Irregular
- **Rate:** Between 120 and 150 beats per minute
- **P wave configuration:** P waves change in appearance from beat to beat. They may be upright, rounded, notched, inverted, biphasic, or buried in the QRS complex.
- **PR interval:** Varies
- **QRS duration and configuration:** Normal in duration and all complexes look alike

Figure 5-14  Multifocal atrial tachycardia.
What's Unique about Multifocal Atrial Tachycardia?

MAT has a clearly changing P wave and a heart rate of 120 to 150 beats per minute.

How the Patient Is Affected and What You Should Know

MAT is usually triggered by an acute attack of emphysema, congestive heart failure (CHF), or acute mitral valve regurgitation. This rhythm should be reported to the licensed practitioner, and the patient’s vital signs and condition should be monitored.

Atrial Flutter

Atrial flutter (A flutter) occurs when a rapid impulse originates in the atrial tissue. The ectopic focus may be originating from ischemic areas of the heart with enhanced automaticity (ability to initiate an electrical current) or from a reentry pathway. A reentry pathway is an extra pathway that has developed where a group of cells will generate an impulse faster than the SA node. This impulse then follows a route that allows the impulse to reach the AV node quicker than the normal conduction pathway. The reentry pathway is similar to finding a shortcut to work or school to bypass the normal traffic route to get you to your destination faster. The electrical current or rhythm is recorded in a characteristic sawtooth pattern (see Figure 5-15). This atrial activity is called flutter (F) waves. Most often this is a transient dysrhythmia that will lead to more serious atrial dysrhythmia if not treated.

Criteria for Classification

- **Rhythm:** The P-P interval or flutter-to-flutter waves will be regular. The interval set with the calipers will stay constant throughout the rhythm. The R-R interval is usually irregular, but occasionally it may be regular in pattern. The regularity of the R-R interval will depend on the ability of the AV node to limit impulses to ventricles.
- **Rate:** The atrial rate will be between 250 and 350 beats per minute.
- **P wave configuration:** P waves are not seen, and only flutter waves are present. These flutter waves resemble a “sawtooth” or “picket fence.” They will be seen best in leads II, III, and aVF. The correlation between...

![Figure 5-15 Atrial flutter.](image-url)
P waves and QRS complexes no longer exists. There will be more flutter waves than QRS complexes, and presence of “F” or flutter waves.

- **PR interval:** No identifiable P wave exists, so the PR interval cannot be measured.
- **QRS duration and configuration:** The QRS duration will be within normal limits of 0.06 to 0.10 second.

### What’s Unique about Atrial Flutter?

Atrial flutter has a “sawtooth” atrial pattern between the QRS complexes.

### How the Patient Is Affected and What You Should Know

The **atrial kick**, which occurs when blood is ejected into the ventricles by the atria immediately prior to ventricular systole, is no longer present since the atria do not contract completely, followed by a delay in the ventricular contraction. This loss in atrial kick contributes to a 10% to 30% decrease in cardiac output. Some patients may tolerate this if the heart rate is within normal limits of 60 to 100 beats per minute. But once the heart rate increases significantly and loss of the atrial kick occurs, the patient will demonstrate signs and symptoms of low cardiac output.

When atrial flutter occurs, notify the licensed practitioner to implement a treatment plan, which usually includes oxygen therapy to ensure adequate supply to the vital organs. The patient is monitored continuously to determine if the rhythm converts to a sinus rhythm or progresses to atrial fibrillation. A continuous rhythm strip is needed to document if any changes occurred as a result of the medical intervention. Always indicate on the rhythm strip the type of intervention that is being implemented. The ECG strips are then mounted and saved in the patient’s medical record or chart.

### Atrial Fibrillation

Atrial fibrillation (A fib.) occurs when electrical impulses come from areas of reentry pathways or multiple ectopic foci. Each electrical impulse results in depolarization of only a small group of atrial cells rather than the whole atria. This results in the atria not contracting as a whole, causing it to quiver, similar to a bowl of Jell-O™ when shaken. Multiple atrial activity is recorded as a chaotic wave, often with the appearance of fine scribbles (see Figure 5-16). No P wave can be identified. The waveform of the chaotic “scribbles” is referred to as fibrillatory waves or “f” waves.

### Criteria for Classification

- **Rhythm:** The P-P interval is unable to be determined because of the fibrillatory waves or f waves. The R-R interval is irregular.
- **Rate:** Atrial rate, if measurable, will be from 375 to 700 beats per minute. It is difficult to determine the atrial rates because each fibrillatory wave is not easy to identify or measure. The ventricular rate is initially
between 160 and 180 beats per minute prior to administering medication. Once medication is provided, the ventricular rate is considered under control if the rate is between 60 and 100 beats per minute.

- **P wave configuration:** The P waves cannot be identified. There is chaotic electrical activity, or “f” waves may be seen.
- **PR interval:** The PR interval cannot be measured, since the P wave is not identifiable.
- **QRS duration and configuration:** The QRS duration and configuration will be within normal limits of 0.06 to 0.10 second and irregular.

**What’s Unique about Atrial Fibrillation?**

Atrial fibrillation shows chaotic disorganized activity between QRS complexes.

**How the Patient Is Affected and What You Should Know**

The patient will exhibit signs and symptoms of decreased cardiac output. The patient usually has limited cardiac function because of preexisting cardiac conditions, so with the loss of atrial kick, the patient’s cardiac output will decrease significantly. Once the heart rate is controlled within the range of 60 to 100 beats per minute, the patient may be able to tolerate the loss of the atrial kick.

Blood will begin to collect in the atria because they are not contracting completely, allowing the opportunity for a clot or thrombus to form. Therefore, the patient has an increased risk of developing and sending an embolism (traveling blood clot) out into the body’s systemic circulation, which can then migrate to other vital organs, such as the lungs or brain. The patient may develop a cerebral vascular accident (CVA), myocardial infarction (MI), pulmonary embolism, renal infarction, or an embolism in any place that the arterial blood is transported. Essentially, the heart is playing Russian roulette with us because there is no way to predict where the embolism will travel in the body to cause serious damage or even sudden death.

Patients who exhibit atrial fibrillation must be observed for low cardiac output. The rhythm needs to be monitored closely as the medication or electrical cardioversion is attempted. Report any complications or vital sign changes to the licensed practitioner immediately.
1. The patient has coronary artery disease. How would you expect PACs to affect this patient?

2. What treatment is usually indicated for patients with atrial flutter?

3. What is the best way to describe the rhythm pattern for atrial fibrillation?

4. Which rhythm is considered more serious, MAT or WAP, and why?

Answer the preceding questions and complete the “Rhythms Originating from the Atria” activity on the student CD under Chapter 5 before you proceed to the next section.

5.5 Rhythms Originating from the Atrial-Junction Node

The atroventricular node is sometimes referred to as the AV junction or AV tissue. Though abnormal, these AV node cells, which possess the property of automaticity, can function as a pacemaker. The inherent rate of the AV node is between 40 and 60 beats per minute. When the AV node instead of the SA node initiates the electrical impulse, the rhythm is referred to as a junctional dysrhythmia. With junctional rhythms, it is important to understand that the electrical current is initiated from the AV junction. Junctional rhythms are suggestive of more serious conditions with the electrical conduction system in the heart. The AV node is the backup pacemaker for the heart after the SA node. Junctional rhythm, accelerated junctional rhythm, and junctional tachycardia are all conditions in which the SA node has been injured and the AV node functions as the pacemaker of the heart.

Premature Junctional Complex

A premature junctional complex (PJC) is a single early electrical impulse that originates in the atroventricular junction. It occurs before the next expected sinus impulse, causing an irregularity in the rhythm (see Figure 5-17).

Criteria for Classification

- **Rhythm:** May be occasionally irregular or frequently irregular depending upon the number of PJCs present
- **Rate:** Will depend upon the underlying rhythm
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- **P wave configuration:** The P wave is inverted and may immediately precede or follow the QRS complex.
- **PR interval:** Will be shorter than normal if the P wave precedes the QRS complex, absent if the P wave is buried in the QRS.
- **QRS duration and configuration:** The QRS duration and configuration will be between 0.06 and 0.10 second, which is within normal limits.

**What's Unique about Premature Junctional Complex?**

PJCs have an irregular rhythm and the P wave is inverted and may appear before, during, or after the QRS complex.

**How the Patient Is Affected and What You Should Know**

When the patient has a healthy heart, isolated PJCs cause no signs or symptoms. If PJCs occur more than four to six per minute, this warns of a more serious condition. An irregular pulse would be noted, and the patient may experience hypotension due to low cardiac output.

**Junctional Rhythm**

Junctional rhythm also known as junctional escape rhythm originates at atrioventricular junctional tissue, producing retrograde (backward) depolarization of atrial tissue, and, at the same time, stimulates the depolarization of ventricles (see Figure 5-18).
Criteria for Classification

- **Rhythm:** The P-P and R-R intervals are regular and at similar intervals. The P-P interval may be difficult to measure due to the location of the P wave.
- **Rate:** If the P wave is identifiable, the rate will be 40 to 60 beats per minute. The ventricular rate will be 40 to 60 beats per minute.
- **P wave configuration:** The P wave is usually inverted and may precede, follow, or fall within the QRS complex. It may not be visible at all on the rhythm strip.
- **PR interval:** If the P wave is before the QRS complex, the PR interval will measure less than 0.12 second and will be constant. If the P wave is not before the QRS complex, the PR interval cannot be determined. This is because this P wave is not associated with the next QRS complex.
- **QRS duration and configuration:** The QRS duration and configuration will be within normal limits of 0.06 to 0.10 second.

What’s Unique about Junctional Rhythm?

A junctional rhythm may have an inverted or absent P wave or a P wave that follows the QRS complex.

How the Patient Is Affected and What You Should Know

The patient has a slower heart rate than normal and loses the atrial kick due to the shortening of the interval between the atrial depolarization and ventricular depolarization. These conditions cause the patient to exhibit symptoms of low cardiac output. Common signs and symptoms of low cardiac output displayed include hypotension (low blood pressure) and altered mental status such as confusion or disorientation. Observe for symptoms and monitor the ECG tracing in case a more serious dysrhythmia occurs. Report the presence of junctional rhythm and your observations of the patient to a licensed practitioner for appropriate medical treatment.

Checkpoint Question 5-5

1. What are differences between a PJC rhythm and a junctional rhythm?

Answer the preceding question and complete the “Rhythms Originating from the Atrial–Junction Node” activity on the student CD under Chapter 5 before you proceed to the next section.
5.6 Supraventricular Dysrhythmias

A supraventricular tachycardia (SVT) is a classification of rapid heartbeats, usually occurring at a rate greater than 150 beats per minute (see Figure 5-19). **Supraventricular** refers to an ectopic focus originating above the ventricles, in the atria, or junctional region of the heart. The heart is beating so fast that it is difficult to determine if the source of origin is from the sinus node, atria, or the AV junction. Because the heart rate is so rapid, the atria are contracting as soon as the ventricles are relaxing. This causes the P waves (atrial contraction) to become difficult to identify, because they may occur at the same time as the T waves (ventricle relaxation). Rhythms that fall into this category are identified in Table 5-3.

The primary difficulty in classifying the actual rhythm is identifying where the tachycardia originates. The P wave may appear before, after, or during the QRS complex, depending on the origin. The PR interval measurement is difficult to assess because you cannot often see the initial upswing of the P wave. Frequently, the licensed practitioner will request the paper speed be increased to pull the cardiac complexes apart for further analysis. However, be sure to mark the tracing if this is done.

**Criteria for Classification**

- **Rhythm:** The ventricular (R-R) rhythm is usually regular or with minimal irregularity from R-R interval. The atrial rhythm may or may not be seen. This is because other electrical activity is occurring at the same time. Remember, the ECG will record only the activity it “sees” in each lead. The atrial activity is small compared to ventricular activity; therefore, the ventricular activity is the largest amount of energy seen when the ECG tracing is recorded. Depending on whether the P waves are seen, you may not be able to determine regular P waves. If identifiable, they are usually regular.

**TABLE 5-3** Dysrhythmias Associated with Supraventricular Tachycardia

<table>
<thead>
<tr>
<th>Sinus Node</th>
<th>Atrium</th>
<th>Junctional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus tachycardia</td>
<td>Atrial flutter</td>
<td>Junctional tachycardia</td>
</tr>
<tr>
<td></td>
<td>Atrial fibrillation</td>
<td></td>
</tr>
</tbody>
</table>
- **Rate:** The ventricular rate is 150 to 350 beats per minute. The atrial rate will be difficult to determine when P waves are unidentifiable.
- **P wave configuration:** The P waves are usually not identified when the heart rate is this rapid. Remember that when the heart rate increases, the time interval between atrial contraction and ventricular relaxation decreases. Therefore, if there is a P wave present, it may occur simultaneously with the T wave and may be buried within it. The P wave may occur before, during, or after the QRS complex.
- **PR interval:** Usually the PR interval is unable to be determined because the beginning of the P wave cannot be clearly identified.
- **QRS duration and configuration:** The QRS measurement is considered within normal limits when measured at 0.06 to 0.10 second.

### What's Unique about Supraventricular dysrhythmias?

Supraventricular dysrhythmias are rate dependent with a rate of greater than 150 beats per minute.

### How the Patient Is Affected and What You Should Know

There are various supraventricular dysrhythmias, all of which may cause the patient to exhibit the same signs and symptoms. The patient may be in either a stable or an unstable condition. The stable patient (one without signs and symptoms of decreased cardiac output) may only complain of palpitations and state, “I’m just not feeling right” or “My heart is fluttering.” When the patient’s condition is **unstable**, he or she may experience any symptom of low cardiac output, which is reflective of the heart not pumping effectively to other body systems. Many patients may present initially with a stable condition and then a few minutes later experience unstable symptoms such as those presented in Table 5-2.

### Scope of Practice

**HIPAA, Law & Ethics**

Your role regarding evaluation of the rhythm strip and assessment of the patient will depend on your training and place of employment. Working outside of your scope of practice is illegal, and you could be held liable for performing tasks that are not part of your role as a health care professional.

Observe the patient for signs and symptoms of low cardiac output. Signs, symptoms, and rhythm changes need to be communicated quickly to a licensed practitioner for appropriate medical treatment. Because tachycardia severely deprives the heart of oxygen, treatment should begin as early as possible. It is difficult to predict how long a patient’s heart can beat at a rapid rate before it begins to affect the other body systems.
1. What are the rate and the origination point of a supraventricular tachycardia?

2. What might you be asked to do when a patient has a supraventricular dysrhythmia?

3. Name the dysrhythmias associated with supraventricular tachycardia.

Answer the preceding questions and complete the "Supraventricular Dysrhythmias" activity on the student CD under Chapter 5 before you proceed to the next section.

5.7 Heart Block Rhythms

In heart block rhythms, the electrical current has difficulty traveling along the normal conduction pathway, causing a delay in or absence of ventricular depolarization. The degree of blockage is dependent on the area affected and the cause of the delay or blockage. There are three levels of heart blocks. The P-P interval is regular with all heart blocks.

First Degree Atrioventricular Block

First degree AV block is a delay in electrical conduction from the SA node to the AV node, usually around the AV node, which prevents an electrical impulse from traveling to the ventricular conduction system (see Figure 5-20). The condition is similar to being in a traffic jam. You still arrive at your destination, but it takes you longer to get there. Electrical current from the SA node will still stimulate ventricular depolarization, but the time it takes to arrive in the ventricles is longer than normal.

Figure 5-20  First degree AV block.
Criteria for Classification

- **Rhythm:** The regularity between the P-P interval and the R-R interval is constant.
- **Rate:** The rate of the atria and ventricles will usually be within normal limits of 60 to 100 beats per minute.
- **P wave configuration:** The P waves will have the same configuration and shape. Each QRS complex will have a P wave before it. There will be the same number of P waves as QRS complexes.
- **PR interval:** The PR interval will be greater than 0.20 second.
- **QRS duration and configuration:** The QRS duration and configuration will be within normal limits of 0.06 to 0.10 second.

What’s Unique about First Degree AV Block?

With first degree atrioventricular block, the PR interval is constant and measures greater than 0.20 second.

How the Patient Is Affected and What You Should Know

The patient will be able to maintain normal cardiac output. No change in the patient should occur with this rhythm. Monitor and observe for further degeneration and development of other heart blocks and report if they occur. It is important to observe the cardiac output parameters—to assess the blood supply to the vital organs—and to determine how well the patient is tolerating the dysrhythmia.

Second Degree Atrioventricular (AV) Block, Mobitz I (Wenckebach)

Second degree heart block has some blocked or nonconducted electrical impulses from the SA node to the ventricles at the atrioventricular junction region. These are impulses that occur too soon after the preceding impulsing, causing a period when no other impulses can occur in the ventricles. However, some electrical impulses are still being conducted along the normal conduction pathway. Second degree heart blocks are the only blocks with an irregular ventricular response.

There are currently two different types of second degree heart blocks, which were first discovered by Dr. Mobitz. Dr. Wenckebach further investigated the rhythm and was able to identify a similar blockage pattern, but it was different from the one Dr. Mobitz observed. The rhythm Dr. Wenckebach observed was specifically labeled second degree atrioventricular block, Mobitz I, although it is often referred to as a Wenckebach rhythm. It is caused when diseased or injured atrioventricular node tissue conducts the electrical impulse to the ventricular conduction pathway with increasing difficulty, causing a delay in time until one of the atrial impulses fails to be conducted or is blocked. After the dropped atrial impulse, the atrioventricular node resets itself to be able to handle future impulses more quickly and then progressively gets more difficult until it drops or is blocked again. This pattern will repeat itself (see Figure 5-21).
Criteria for Classification

- **Rhythm:** The P-P interval will be regular. The R-R interval will be irregular due to the blocked impulse(s).
- **Rate:** Atrial rate will be within normal limits. The ventricular rate will be slower than the atrial rate.
- **P wave configuration:** The P wave configuration will be normal size with an upright P wave. There will be a P wave for every QRS complex, but there will be extra P waves.
- **PR interval:** The PR interval will vary from one measurement to the next. The PR interval will be progressively longer with each subsequent conducted P wave until the QRS wave is dropped. The PR interval will be short, and then the cycle will begin again.
- **QRS duration and configuration:** The QRS duration and configuration should be within normal limits of 0.06 to 0.10 second.

What’s Unique about Second Degree AV Block Mobitz I (Wenckebach)?

A Mobitz I rhythm has a cyclical extending PR interval until the QRS is dropped. Then the cycle begins again (irregular ventricular response).

How the Patient Is Affected and What You Should Know

The patient may or may not exhibit symptoms of decreased cardiac output, depending on the heart rate of the ventricles. As this rate decreases and reaches levels of 40 beats per minute or lower, the patient will show signs and symptoms of low cardiac output. This rhythm is usually due to inflammation around the atrioventricular node, and it is often a temporary condition that will resolve itself and return to a normal heart rhythm.

Since treatment is based on how the patient is tolerating the rhythm, the patient is observed for signs and symptoms of low cardiac output. If the patient is experiencing difficulties, a licensed practitioner administers medication; if not, the patient is monitored for further progression to third degree heart block.
Second Degree Atrioventricular (AV) Block, Mobitz Type II

Second degree atrioventricular block, Mobitz II, is often referred to as the classical heart block because it was the first rhythm observed to have an occasional dropped complex (see Figure 5-22). The atrioventricular node selects which electrical impulses it will block. No pattern or reason for the dropping of the QRS complex exists. Frequently this dysrhythmia will progress to third degree atrioventricular block.

Criteria for Classification

- **Rhythm:** The P-P interval will be regular. The R-R interval will be irregular due to the blocked impulse(s).
- **Rate:** Atrial rate will be within normal limits. The ventricular rate will be slower than the atrial rate. The atrial and ventricular rates will not be the same.
- **P wave configuration:** The P wave configuration will be normal, with a normal size and upright wave. There will be a P wave for every QRS complex, but there will be more P waves than QRS complexes.
- **PR interval:** The PR interval is constant and will remain constant even after the QRS drop occurs.
- **QRS duration and configuration:** The QRS duration and configuration should be within normal limits of 0.06 to 0.10 second.

What's Unique about Second Degree (AV) Block, Mobitz Type II?

A Mobitz II rhythm has a constant PR interval with blocked QRS complexes (irregular ventricular response).

How the Patient Is Affected and What You Should Know

Observe the patient for signs and symptoms of low cardiac output since this rhythm frequently will progress very quickly to a third degree atrioventricular block or complete heart block (CHB), usually within seconds. Recognition of the classical block pattern versus the Wenckebach pattern is essential. See Table 5-4 for differences between second degree heart blocks. The classical block is more critical and can quickly lead to a complete heart block and a Code Blue situation. When your patient is experiencing second degree heart block, Mobitz II, you should immediately report it to a licensed
Mobitz I versus Mobitz II

To quickly determine the difference between a second degree, Mobitz I (Wenckebach), and a second degree, Mobitz II (classical rhythm), atrioventricular block, look for the dropped beat indicated by a missing QRS complex. For the Wenckebach rhythm, the PR interval in front of the dropped QRS complex will be longer than the PR interval after the dropped QRS complex. Remember the mnemonic “Lengthen, Lengthen, drop equals Wenckebach.” For the classical rhythm, the PR interval in front and behind the dropped QRS complex will be constant. Both rhythms should be reported; however, the classical rhythm is a critical condition, unlike the Wenckebach rhythm, which will usually resolve itself.

What does the mnemonic “Lengthen, Lengthen, drop equals Wenckebach” mean?

Third Degree Atrioventricular (AV) Block

Third degree atrioventricular block is also known as third degree heart block or complete heart block (CHB). All electrical impulses originating above the ventricles are blocked and prevented from reaching the ventricles. There is no correlation between atrial and ventricular depolarization. As a result, there will be noticeable and suspicious disassociation properties; namely the P-P and R-R intervals. Although the intervals are regular when measured, the atria and ventricles will be firing at completely different rates. This is due to the “block,” and as a result the ventricular rate will be slower than the atrial rate (see Figure 5-23).

The rate of the ventricular response and the configuration of the QRS complex will be dependent upon the level of the block. If the block is low in the bundle of His, the pacemaker would come from the slow (20 to 40 beats

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**TABLE 5-4 Differences Between Second Degree Heart Blocks**

<table>
<thead>
<tr>
<th>Type of Heart Block</th>
<th>PR Interval</th>
<th>Etiology</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second degree AV block, Mobitz I (Wenckebach)</td>
<td>Varies from one complex to another; will reset itself after the dropped complex</td>
<td>Temporary</td>
<td>May resolve itself; observe cardiac output and wait until the PR intervals vary and the dropped QRS complexes occur</td>
</tr>
<tr>
<td>Second degree AV block, Mobitz II (classical block)</td>
<td>Constant PR interval throughout the rhythm strip</td>
<td>Chronic situation</td>
<td>Quickly leads to a complete heart block, a life-threatening situation that needs immediate attention: call 911 or Code Blue</td>
</tr>
</tbody>
</table>

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practitioner; and, if trained, you should prepare for a Code Blue and application of a temporary external pacemaker.
per minute) Purkinje network. The QRS complex in this instance would measure 0.12 second or greater.

If the block is higher and the impulse causing ventricular depolarization is coming from the area of the AV tissue, then the rate is likely to be 40 to 60 beats per minute and the QRS complex will present with a “normal to narrow” appearance measuring 0.06 to 0.10 second. The ventricular rate and QRS configurations are keys indicating the level of the heart block.

Criteria for Classification

- **Rhythm:** The P-P interval is regular. The R-R interval is also regular, but the P-P and R-R intervals will be different.
- **Rate:** The atrial rate will be within normal limits of 60 to 100 beats per minute. The ventricular rate is slow, between 20 and 40 beats per minute.
- **P wave configuration:** P waves will be of normal size and configuration, but the location may be buried within the QRS, either before or after the QRS complex. There will be no correlation seen between the P waves and the QRS complex. More P waves will be noted than QRS complexes, and not every P wave will have a QRS complex following it.
- **PR interval:** Appearance of a pattern consisting of a long PR interval followed by a short PR interval is a clue that a complete heart block exists.
- **QRS duration and configuration:** The QRS duration and configuration will be the same but the measurements may be either within normal limits or wide, depending on the area of the blockage.

What’s Unique about Third Degree (Complete) Heart Block?

In third degree atrioventricular block, the P-P and R-R intervals are regular (constant) but firing at different rates.

How the Patient Is Affected and What You Should Know

The patient has lost coordination between the atria and ventricles; therefore, the atrial kick is lost. Along with the loss of atrial kick and reduced heart rate, the patient will exhibit signs and symptoms of low cardiac output. Often the patient will be unconscious and require immediate medical intervention.

In a situation where the patient is in third degree AV block, your first responsibility is to observe the patient for symptoms of low cardiac output. If the patient displays any signs and symptoms, a licensed practitioner...
needs to be contacted immediately. Initiating a Code Blue procedure makes this contact. A temporary pacemaker should be available and ready for application as deemed necessary by the licensed practitioner. All rhythm strips should be mounted and identified in the patient’s medical record as documentation of the dysrhythmia.

**Checkpoint Questions 5-7**

1. Name the heart block rhythms described in this section. Which one is most serious?

2. How can you tell the difference between a Mobitz I and Mobitz II heart block?

3. What should you do if the patient has a third degree heart block?

Answer the preceding questions and complete the “Heart Block Rhythms” activity on the student CD under Chapter 5 before you proceed to the next section.

**5.8 Bundle Branch Block Dysrhythmias**

**Bundle branch blocks** occur when one or both of the ventricular pathways are damaged or delayed due to cardiac disease, drugs, or other conditions. When an area of one of the bundle branches is damaged, electrical current will not be able to travel through that tissue to reach the myocardial tissue in its usual fashion. Current will travel down the good bundle and will activate the myocardial tissue in that corresponding ventricle only. The other ventricle must then receive the impulse as current travels from one cell to the next until the entire myocardial contraction occurs. It is similar to the knocking down of a line of dominoes where each domino represents a cardiac cell. The cell will not contract until the next cell delivers the energy.

Current not traveling the normal pathways will take longer to achieve the full ventricular contraction. This longer time frame is similar to driving a car to a specific destination and having to find an alternate route or detour when the road is closed. This is what happens to the current traveling through the heart's conduction pathway when it has a blocked bundle branch. The increased length of time is reflected in the QRS duration. Remember that the QRS duration is a measurement of just how long it takes for current to travel through ventricular myocardial tissue.

When a patient has a right bundle branch block (RBBB), the impulse will travel down the conduction pathway normally until after the bundle of His.
Since the right side of the conduction pathway is blocked, current must travel down the left bundle branch to activate the ventricles (see Figure 5-24A).

The left bundle branch block (LBBB) will have the left conduction pathway blocked. Current travels down the right bundle branch to cause the right ventricle, the septum, then the left ventricle to contract (see Figure 5-24B).

The bundle branch block classification provides additional information about another dysrhythmia. Information regarding a bundle branch block is extra data included with the basic rhythm classification. Typically the basic rhythm will be a rhythm that originates from above the ventricles. The rhythm has all the basic properties of sinus rhythms or atrial dysrhythmias with the exception of a wide QRS complex. The discovery of a wide QRS complex is the clue to further investigate for the bundle branch block. For example, the patient may be experiencing sinus rhythm with a left bundle branch block (sinus rhythm with left bundle branch block). The basic rhythm must always be determined with the distinction of a right bundle branch block or left bundle branch block present.

### Criteria for Classification

Characteristics of the right and left bundle branch block will be similar over monitoring leads I, II, and III. Specific characteristics of the right or left bundle branch will be present when monitoring with leads V1 to V6. Although bundle branch block (BBB) is seen in the precordial leads, to distinguish RBBB from LBBB, lead VI is referenced. If the QRS is positively deflected, it is an RBBB. If the QRS is negative, it is an LBBB.
**Rhythm:** The regularity or irregularity will depend on the underlying rhythm. Sinus or atrial is usually the underlying rhythm, with both regular and irregular rhythm patterns possible.

**Rate:** The atrial and ventricular rates will depend on the basic rhythm.

**P wave configuration:** The shape, configuration, deflection, and coordination with the QRS complex will depend on the basic rhythm.

**PR interval:** The PR interval will be a normal measurement of 0.12 to 0.20 second.

**QRS duration and configuration:** The QRS measurement will be 0.12 second or greater in length. The widening of the QRS duration indicates the presence of a bundle branch block.

**How the Patient Is Affected and What You Should Know**

The patient will exhibit the normal effects of the basic rhythm he or she is experiencing. For example, if the rhythm is sinus tachycardia, the patient will exhibit the sign and symptoms of a fast heart rate. A bundle branch block condition can further deteriorate to the development of another bundle branch block. If the current becomes totally blocked and current cannot reach the myocardium, this is considered a complete heart block.

Initially, you will observe a widening of the QRS complex, which indicates the presence of a bundle branch block. This should be reported to a licensed practitioner immediately. The patient will need to be monitored further by the licensed practitioner to determine whether an RBBB or LBBB pattern is present, and the patient’s condition should be observed for deterioration. All patients must have a 12-lead ECG to document the bundle branch block. If further degeneration of the conduction system occurs, treatment may be a pacemaker. Pacemakers are applied to the external skin for a temporary condition for only 24 hours at a time. The patient may end up in a Code Blue situation and/or needing a permanent pacemaker.

**Checkpoint Questions 5-8**

1. What happens when one or both of the ventricular pathways are not functioning properly due to damage or a delay from cardiac disease, drugs, or other conditions?

2. Describe the electrical conduction for the RBBB and an LBBB.

Answer the preceding questions and complete the “Bundle Branch Block Dysrhythmias” activity on the student CD under Chapter 5 before you proceed to the next section.
5.9 Rhythms Originating from the Ventricles

As discussed in Chapter 2, the ventricle pacemaker cells are found at the Purkinje fibers (see Figure 2-9). This pacemaker is the last of the group of inherent pacemaker cells within the heart. The rate of automaticity is between 20 and 40 beats per minute. Current is initiated within the Purkinje fibers and spreads the electrical stimulation from one ventricular cell to the next. Since current is not traveling down the normal ventricular conduction pathway to activate both the right and left ventricles simultaneously, it will take longer than normal to depolarize the ventricles. A QRS duration and configuration measurement of 0.12 second or greater suggests that this cell-by-cell stimulation of electrical current is occurring to depolarize the ventricles.

Premature Ventricular Complexes

A premature ventricular complex (PVC) is caused by an ectopic beat that occurs early in the cycle and originates from the ventricles (see Figure 5-25). Table 5-5 shows the various types of premature ventricular complexes.

<table>
<thead>
<tr>
<th>TABLE 5-5</th>
<th>Types of Premature Ventricular Complexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unifocal</td>
<td>Early beat (has similar shape and shape suggesting only one irritable focus present)</td>
</tr>
<tr>
<td>Multifocal</td>
<td>Varied shapes and forms of the PVCs</td>
</tr>
<tr>
<td>Interpolated</td>
<td>PVC occurs during the normal R-R interval without interrupting the normal cycle</td>
</tr>
<tr>
<td>Occasional</td>
<td>More than one to four PVCs per minute</td>
</tr>
<tr>
<td>Frequent</td>
<td>More than five to seven PVCs per minute</td>
</tr>
<tr>
<td><strong>Bigeminy</strong></td>
<td>Every other beat is a PVC</td>
</tr>
<tr>
<td>Trigeminy</td>
<td>Every third beat is a PVC</td>
</tr>
<tr>
<td><strong>Quadgeminy</strong></td>
<td>Every fourth beat is a PVC</td>
</tr>
<tr>
<td>R on T PVCs</td>
<td>PVC occurs on the T wave or the vulnerable period of the ventricle refractory period</td>
</tr>
<tr>
<td>Coupling</td>
<td>Two PVCs occur back to back</td>
</tr>
</tbody>
</table>
Criteria for Classification

- **Rhythm:** The P-P and R-R intervals will be regular with early QRS complexes. Every early complex has a full compensatory pause, meaning that two R-R interval periods are required before another electrical impulse can be conducted. These two R-R intervals are placed on the beat before the early complex and evaluated with the following complex if the QRS complex falls after the second point of the calipers.
- **Rate:** The atrial and ventricular rates will be the same as for the underlying rhythm, but the early complexes will provide a faster ventricular rhythm than the normal rhythm.
- **P wave configuration:** The P wave assumes the shape of the underlying rhythm. P waves are not identified on the early ventricular complex.
- **PR interval:** The PR interval measurement follows the underlying rhythm, but in the early complex there is no P wave present.
- **QRS duration and configuration:** The QRS duration measurement follows the underlying rhythm. With the early complexes, the QRS duration must be greater than 0.12 second and will have a bizarre form. The QRS shape will have a QRS wave in one direction and a T wave going in the opposite direction.

What’s Unique about Premature Ventricular Complexes?

A PVC is an early QRS complex that is wide (>0.12 second) and has a bizarre appearance. There is no P wave.

How the Patient Is Affected and What You Should Know

The clinical significance of the PVCs will depend on their frequency and the amount of decrease in cardiac output that occurs with each PVC. Since PVCs can occur in normal hearts, patients may tolerate PVCs without a noticeable change in their cardiac output and have no obvious symptoms. In fact, they may be unaware they are having PVCs. Other patients may complain of the “thump or skipping” sensation with each PVC. They may also experience dizziness and other symptoms of low cardiac output. More complex PVCs, such as frequent, multifocal, R-on-T PVCs and coupling, indicate an increased risk of developing a more serious ventricular dysrhythmia (see Table 5-5).

Observe the patient for symptoms of low cardiac output. If symptoms exist, a licensed practitioner should be notified to begin appropriate treatment. Patients are provided oxygen, since PVCs often occur because of hypoxic states (suffering from lack of oxygen). Blood samples are drawn to evaluate the hypoxic state as well as electrolyte values, specifically potassium and calcium levels.

Idioventricular Rhythm

Idioventricular rhythms occur when the sinoatrial and junctional pacemakers fail to initiate an impulse and all that is remaining is the slow ventricular pacemaker (20 to 40 beats per minute). This dysrhythmia presents with the classic “wide” QRS (0.12 second or greater), a slow ventricular rate (20 to 40), and an absence of P waves (see Figure 5-26).
Criteria for Classification

- **Rhythm:** P-P interval cannot be determined. R-R interval is regular.
- **Rate:** Atrial rate cannot be determined due to the absence of atrial depolarization. The ventricular rate is 20 to 40 beats per minute.
- **P wave configuration:** The P wave is usually absent; therefore, no analysis of the P wave can be done.
- **PR interval:** The PR interval cannot be measured because the P wave cannot be identified.
- **QRS duration and configuration:** The QRS duration and configuration measures 0.12 second or greater and will have the classic ventricular “wide-bizarre” appearance.

What’s Unique about Idioventricular Rhythm?

An idioventricular rhythm has an absence of P waves, slow ventricular rate of 20 to 40 beats per minute, and wide-bizarre QRS complexes.

How the Patient Is Affected and What You Should Know

The patient has a profound loss of cardiac output due to the loss of atrial kick and the slow ventricular rate. The patient will likely be unconscious. You must notify a licensed health care practitioner immediately. This is a medical emergency that will likely require treatment with cardiac medications and/or pacing. ECG strips obtained must be saved and mounted in the patient’s medical record.

Accelerated Idioventricular Rhythm

Accelerated idioventricular rhythms occur when the sinoatrial and junctional pacemakers fail to initiate an impulse and all that is remaining is the slow ventricular pacemaker. The primary difference between accelerated idioventricular and idioventricular dysrhythmias is the heart rates. This dysrhythmia still presents with the classic “wide” QRS (0.12 second or greater) complex and an absence of P waves. The impulse rate for this dysrhythmia is 40 to 100 beats per minute. It is simply a faster idioventricular rhythm (see Figure 5.27).
Criteria for Classification

- **Rhythm:** P-P interval cannot be determined. R-R interval is regular.
- **Rate:** Atrial rate cannot be determined due to the absence of atrial depolarization. The ventricular rate is 40 to 100 beats per minute.
- **P wave configuration:** The P wave is usually absent; therefore, no analysis of the P wave can be done.
- **PR interval:** The PR interval cannot be measured because the P wave cannot be identified.
- **QRS duration and configuration:** The QRS duration and configuration measures 0.12 second or greater and will have the classic ventricular “wide-bizarre” appearance.

What’s Unique about Accelerated Idioventricular Rhythm?

The accelerated idioventricular rhythm has an absence of P waves, a ventricular rate of 40 to 100 beats per minute, and wide-bizarre QRS complexes.

How the Patient Is Affected and What You Should Know

The patient may or may not be able to tolerate this dysrhythmia due to the decrease of cardiac output as a result of the loss of atrial kick and the slower ventricular rate. The patient may or may not be unconscious. You must notify a licensed health care practitioner immediately. This patient may require treatment with cardiac medications and/or pacing. ECG strips obtained must be saved and mounted in the patient’s medical record.

Ventricular Tachycardia

Ventricular tachycardia occurs when three or more PVCs occur in a row and the ventricular rate is greater than 100 beats per minute (see Figure 5-28). The ventricles are essentially in a continuous contraction-relaxation pattern and no period of delay exists between depolarization (contraction).

Criteria for Classification

- **Rhythm:** The P-P interval is usually not identifiable due to the large ventricular activity recorded. The R-R interval is usually regular, but it may be slightly irregular at times.
● **Rate:** Atrial rate cannot be determined because the P-P interval cannot be recognized. The ventricular rate is between 100 and 200 beats per minute.

● **P wave configuration:** The P wave is usually absent; therefore, no analysis of the P wave can be done.

● **PR interval:** The PR interval cannot be measured because the P wave is not able to be identified.

● **QRS duration and configuration:** The QRS duration and configuration measures greater than 0.12 second and will have a bizarre appearance with an increase in amplitude. The T wave will be in the opposite direction (usually downward) from that of the QRS complex.

**What’s Unique about Ventricular Tachycardia?**

Ventricular tachycardia has a classic “sawtooth” appearance and a rate in excess of 100 beats per minute, with no P wave.

**How the Patient Is Affected and What You Should Know**

The patient will have a decrease in cardiac output due to the decrease in ventricular filling time and the loss of the atrial kick. Some patients can tolerate the dysrythmia for a short time and will have a pulse and remain conscious, whereas other patients will be unresponsive immediately. About 50% of the patients will become unconscious immediately, with no pulse or respiration.

**Troubleshooting**

**Escape Beats**

PVCs, called “escape beats,” can often occur when the heart rate is less than 60 beats per minute. This is the heart’s effort to pick up the rate. The PVCs are occurring because of the bradycardia, not because of hypoxia or abnormal lab values.

Which of the following would most likely be the cause of a PVC: oxygen saturation of 89% or heart rate of 46 beats per minute?
As soon as you recognize ventricular tachycardia on the monitor or ECG equipment, you should notify a licensed practitioner as the patient will need to be assessed for unresponsiveness. If the patient is unresponsive, a Code Blue is called and CPR is initiated. Emergency equipment such as a defibrillator, medications, and intubation equipment are necessary. Rhythm strips are saved to document the changes in rhythm that have occurred and should be mounted in the patient’s medical record. If the patient is responsive, the licensed practitioner may initiate a treatment plan of medications and electrical treatments.

**Agonal Rhythm**

Agonal rhythms occur when essentially all of the pacemakers in the heart have failed. This is the last semblance of ordered electrical activity in the heart. The heart is dying. The impulses showing on the monitor are ventricular but firing at a rate of less than 20 beats per minute. This dysrhythmia presents with “wide-bizarre” QRS (0.12 second or greater) complexes, and an absence of P waves (see Figure 5-29).

**Criteria for Classification**

- **Rhythm:** P-P interval cannot be determined. R-R interval may or may not be regular.
- **Rate:** Atrial rate cannot be determined due to the absence of atrial depolarization. The ventricular rate is less than 20 beats per minute.
- **P wave configuration:** The P wave is absent; therefore, no analysis of the P wave can be done.
- **PR interval:** The PR interval cannot be measured because the P wave cannot be identified.
- **QRS duration and configuration:** The QRS duration and configuration measures 0.12 second or greater and will have a “wide-bizarre” appearance.

**What’s Unique about Agonal Rhythm?**

The accelerated idioventricular rhythm has an absence of P waves, a ventricular rate of less than 20 beats per minute, and wide-bizarre QRS complexes.
How the Patient Is Affected and What You Should Know

The patient has a profound loss of cardiac output due to the loss of atrial kick and the slow ventricular rate. The patient will be unconscious. You must notify a licensed health care practitioner immediately. This is a medical emergency that will likely require both basic life support and advanced cardiac life support interventions. ECG strips obtained must be saved and mounted in the patient’s medical record.

Ventricular Fibrillation

Ventricular fibrillation is chaotic asynchronous electrical activity within the ventricular tissue. The ventricle walls are quivering, preventing any movement of blood out of the ventricles, which results in no cardiac output (see Figure 5-30). The entire myocardium is quivering similar to a bowl of Jell-O™ when shaken.

Criteria for Classification

- **Rhythm:** Both the P-P and R-R intervals cannot be determined because only chaotic waveforms are recorded on the rhythm strips. If an R-R interval is determined, it will be irregular.
- **Rate:** The atrial rate cannot be determined or identified. The ventricular rate, if identifiable, is greater than 300 beats per minute.
- **P wave configuration:** The P wave configuration is not identifiable.
- **PR interval:** The PR interval cannot be identified.
- **QRS duration and configuration:** The QRS duration and configuration cannot be determined because only fibrillatory waves are present without any uniform depolarization of the ventricle occurring.

What’s Unique about Ventricular Fibrillation?

Ventricular fibrillation is the absence of organized electrical activity. The tracing is chaotic in appearance.
**Crash Cart**

Emergency equipment found on the “crash cart” must be ready when a code situation occurs. It is important that the cart be well stocked and the emergency equipment functioning properly. Each facility has a policy that requires regular checking and documentation of all emergency equipment and “crash carts.”

**How the Patient Is Affected and What You Should Know**

If the patient is conscious and talking but the ECG tracing is showing ventricular fibrillation, the patient’s electrodes have become loose or detached.

In true ventricular defibrillation, patients will be unresponsive when the ventricles are quivering without contracting. This will always be a Code Blue situation, in which immediate intervention is necessary to prevent biological death. Every patient experiencing ventricular fibrillation will be unconscious, apneic (apnea means not breathing), and pulseless. CPR and emergency measures should begin immediately. It is recommended that appropriate personnel begin the advanced cardiac life support (ACLS) to regain normal cardiac function. Rhythm strips are maintained and used as documentation in the patient’s medical record.

**Asystole**

Asystole is absence of ventricular activity and depolarization. Often this is called “the straight or flat line” of rhythms. No electrical activity is present in the myocardium (see Figure 5-31).

**Criteria for Classification**

- **Rhythm:** Since no waveforms are present, there are no P-P or R-R intervals.
- **Rate:** No atrial or ventricular rates are present.
- **P wave configuration:** No P waves are present.
- **PR interval:** The PR interval is unable to be measured because no waveforms are being recorded.
- **QRS duration and configuration:** The QRS duration and configuration is not measurable because no QRS waveform is observed.

**Figure 5-31** Asystole.
How the Patient Is Affected and What You Should Know

This rhythm is associated with life-threatening conditions. The patient will display no pulse and no cardiac output as evidenced by unconsciousness and apnea. The patient is in cardiac arrest, and emergency procedures must be initiated immediately.

**Checkpoint Questions 5-9**

1. What is the difference between idioventricular rhythm and accelerated idioventricular rhythm?

2. How are agonal rhythm and asystole the same?

3. What is the difference between ventricular tachycardia and ventricular fibrillation?

Answer the preceding questions and complete the “Rhythms Originating from the Ventricles” activity on the student CD under Chapter 5 before you proceed to the next section.

**Handling Emergency Situations**

During an emergency, family, friends, and other patients will be apprehensive and curious regarding the situation. You should calmly explain that there is an emergency and escort individuals out of the immediate area and view of the situation. Explain to any family members that a licensed practitioner will speak to them concerning their loved one as soon as possible.

**5.10 Electronic Pacemaker Rhythms**

Electronic pacemakers, also known as artificial pacemakers, are devices that deliver an electrical impulse to the myocardium to cause the cells to depolarize. This electrical generator will provide small amounts of electrical current in a predetermined interval to mimic the normal pacemaker of the heart. Pacemakers have the capability to pace the atria, ventricles, or both chambers. They are sometimes temporary but are usually implanted under the skin (see Figure 5-32) to correct dysrhythmias. Although many different types of electronic pacemakers are implanted, the mode in which they function varies in only a few ways. Because of the variety of pacemakers
available on the market, it is recommended that you check in advance regarding the proper procedure for performing an ECG on a patient with a pacemaker.

**Figure 5-32** Implanted pacemaker.

Pacemaker leads
Right atrium
Right ventricle

The pacemaker’s electrical current will not be dangerous to you or other people who encounter the patient. The skin does not conduct electricity so current will not be transmitted to another person from the pacemaker.

The fastest pacemaker in the heart controls the heartbeat, whether it is an inherent pacemaker, such as the SA node, or an artificial one. Electronic pacemakers work based on this principle. For example, when a patient is experiencing a bradycardia dysrhythmia, an artificial pacemaker is used and set at a rate of 70 or 72 beats per minute. This artificial pacemaker will be the fastest pacemaker in the heart and thus will control the heart rate for the myocardium.

Pacemakers can stimulate several different cardiac functions. The stimulation may be for the atria, the ventricles, or both. The function will depend on the reason the pacemaker is inserted. For example, if the patient is experiencing problems with the conduction system in the ventricles, a ventricular pacemaker is inserted to deliver direct stimulation to the ventricles and produce a ventricular contraction. Atrial pacing is used alone when the conduction system from the atrioventricular node through the ventricles is intact and functioning.

Atrioventricular pacing provides direct stimulation of the atria and ventricles in a sequence pattern known as atrioventricular sequential pacing. This pacing option mimics the normal cardiac conduction system. It allows for the atria to contract completely prior to the ventricles to allow for an atrial kick. (*Remember that the atrial kick provides the extra blood supply needed for approximately 10% to 30% of the normal cardiac output.*) This pacing function is being used more when pacemakers are inserted because
it will mimic normal cardiac function and provide the atrial kick needed. A newer type of atrioventricular sequential pacing is atrobiventricular pacing used commonly in patients with heart failure. Both ventricles are stimulated to contract compared to usually only the lower portion of the right ventricle being stimulated.

**Evaluating Pacemaker Function**

Pacemaker function can be evaluated based on the ECG tracings. Several different ECG characteristics must be identified prior to evaluating the pacemaker function. The most important aspect of care is to verify the effectiveness of the pacemaker and determine the presence of a pulse with each captured beat. (Capture refers to the ability of the heart muscle to respond to electrical stimulation and depolarize the myocardial tissue.)

**Pacing Spike**

The pacing spike or artifact indicates the stimulation of electrical current from the pacemaker generator. The current is a quick delivery and is reflected as a thin spike on the ECG tracing (see Figure 5-33). After the pacing spike, a tracing of either a P wave or a wide QRS complex or both will appear, depending on which chamber is being paced.

**Chamber Depolarization Characteristics**

If the pacemaker delivers atrial pacing, the pacing spike will be followed by a P wave. When the pacemaker delivers ventricular pacing, the pacing spike will be followed by a wide QRS complex, which looks similar to an RBBB pattern. The ventricles are stimulated low in the right ventricle, causing the myocardium to depolarize slowly. The complex is wide and shaped differently from a natural QRS complex. It is similar to the RBBB since the left ventricle takes longer than the right to depolarize because of its size.

**AV Delay**

The AV sequential pacemaker tracing will have an atrioventricular delay. An atrioventricular delay is similar to the measurement of the PR interval on a
normal rhythm tracing. It is measured from the atrial spike to the ventricle spike. Usually this programmed time frame is somewhere between 0.12 to 0.20 second, similar to a normal PR interval.

If the patient has a normal P wave and a pacer-induced ventricular complex, the atrioventricular delay is determined from the beginning of the P wave to the ventricular spike. If the patient has a pacer-induced atrial complex and a normal QRS measurement, the measurement from the pacing spike to the beginning of the QRS complex should be less than the set atrioventricular delay time frame.

**Evaluating a Pacemaker ECG Tracing**

Evaluating a pacemaker rhythm involves seven steps, which are similar to those used to evaluate a nonpaced rhythm. If a patient does not have an atrioventricular sequential pacemaker, steps 3 through 5 can be eliminated. In addition, it is important to estimate the frequency of the pacemaker initiating the rhythm compared to the patient's inherent rhythm. The estimates are usually referred to in 25% intervals. If the entire rhythm strip displays an atrioventricular paced rhythm, it is referred to as 100% atrioventricular pacing (1:1). *(When less than 100% paced rhythm occurs, identify the patient's inherent rhythm and then include the estimate of paced beats and the type of pacing function as seen on the rhythm strip.)*

**Step 1. What are the rate and regularity of the paced rhythm?**

The regularity of the pacemaker spikes should be exactly the same. Only if the patient's own rhythm becomes faster than the pacemaker will the regularity be different. The rate of the pacemaker rhythm should be exactly the number at which the pacemaker was set. Often the rate is set at 70 beats per minute.

**Step 2. What are the rate and regularity of the intrinsic rhythm (the patient's own rhythm)?**

When the patient's own heart rate beats faster than the pacemaker rhythm, the patient's intrinsic rhythm will control the heart rate. The patient's own rhythm should be noted on the ECG tracing. The rate and regularity will depend on the patient's inherent rhythm.

**Step 3. Is the atrial lead sensing appropriate?** *(For AV sequential pacemakers only)*

The ECG tracing needs to be evaluated for the presence of atrial spikes with the P wave following the spike. Occasionally, the patient's own SA node or atrial ectopic focus will initiate atrial contraction as evidenced by a P wave without an atrial spike.

**Step 4. Is atrial capture present?** *(For AV sequential and atrioventricular pacemakers)*

Every atrial spike should have a P wave after it to indicate that the electrical current is causing the cells to depolarize. The P wave after the spike indicates that the atrial capture occurred.
Step 5. Is atrioventricular delay appropriate? (For atrioventricular sequential and atrio-biventricular pacemakers)

Measuring from the atrial spike to the ventricular spike, or from the beginning of the P wave to the ventricular spike, will give you the atrioventricular delay interval. This time frame should be the same as the atrioventricular delay set on the pacemaker program. This information should be available on the patient’s medical record or pacemaker information card.

Step 6. Is ventricular sensing appropriate?

The ECG tracing needs to be evaluated for the presence of ventricular spikes with the wide QRS complex following the spike. Occasionally the patient’s own conduction system will work appropriately, as evidenced by a normal P wave and/or QRS complex. If the ventricular contraction occurred normally before the time interval of when the pacemaker would send a ventricular impulse, the pacemaker generator will be inhibited, or stopped. This is evidenced by the absence of a ventricular spike.

Step 7. Is ventricular capture present?

Every ventricular spike should have a wide QRS complex after it to indicate that the electrical current caused the cells to depolarize. Appearance of the QRS complex after the spike indicates that ventricular capture occurred.

Pacemaker Complications Relative to the ECG Tracing

Pacemaker generators use lithium batteries to create an electrical impulse. As with any battery, the charge of the battery will decrease to the point at which the battery needs to be replaced. If a pacemaker is losing its ability to function properly, this failure will be evident on the ECG tracings. These changes in rhythms are often referred to as complications of the pacemaker. Complications include slower firing rates than set, less effective sensing capabilities, and lower electrical current than predetermined.

Another pacemaker complication is related to the functioning of the pacemaker generator when the sensing capability is too low. If sensing capability is low, the pacemaker will not be able to “see” the normal contractions occurring in the sensing chamber. Therefore, electrical impulses will not be inhibited but may actually be triggered, sending an impulse to the myocardium because the normal electrical current of the heart’s conduction system was not “seen.”

There are several different reasons for pacemaker complications, but only four basic dysrhythmias are evident on the ECG tracing from these complications: malfunctioning (failure to pace), malsensing (failure to sense), loss of capture (failure to depolarize), and oversensing (perceiving electrical current from sources other than the heart) (see Table 5-6).

Responsibility in caring for patients with pacemakers requires recognizing normal pacemaker rhythms and possible complications. When you are performing an ECG or monitoring a patient with a pacemaker, you should be aware of the differences in the ECG waveforms, including the
### TABLE 5-6 Pacemaker Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cause</th>
<th>What Occurs</th>
<th>Patient Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malfunctioning (failure to pace)</td>
<td>Pacemaker does not send electrical impulse to the myocardium.</td>
<td>Pacemaker intervals are irregular and impulse is slower than set rate. No pacemaker spike is seen.</td>
<td>Patient will most often experience hypotension, lightheadedness, and blackout periods due to bradycardia conditions.</td>
</tr>
<tr>
<td>Malsensing (failure to sense)</td>
<td>Pacemaker does not sense the patient’s own inherent rate.</td>
<td>May send current to heart during relaxation (repolarization) phase; also known as pacemaker competition with the patient’s own heart</td>
<td>With atrial pacing, atrial fibrillation can occur; with ventricular pacing, ventricular tachycardia or ventricular fibrillation can occur.</td>
</tr>
<tr>
<td>Loss of capture (failure to depolarize)</td>
<td>Pacing activity occurs but myocardium is not depolarized.</td>
<td>Pacing spikes will occur without capture waveform such as P wave or QRS complex (see first figure).</td>
<td>Symptoms depend on the basic dysrhythmia and the patient’s condition prior to the pacemaker insertion.</td>
</tr>
<tr>
<td>Oversensing</td>
<td>Pacemaker perceives electrical current from sources other than the heart.</td>
<td>Either (1) the patient’s own heart rate is recorded and is slower than the set rate of the pacemaker or (2) the pacemaker spikes and captures at a slower rate than set (see second figure).</td>
<td>Patient may have signs and symptoms of low cardiac output.</td>
</tr>
</tbody>
</table>

presences of a pacing spike, chamber depolarization characteristics, and an atrioventricular delay. If you observe complications of a pacemaker rhythm, immediately notify licensed personnel for appropriate treatment and interventions.
1. Name and describe four different reasons for pacemaker complications.

Answer the preceding question and complete the “Electronic Pacemaker Rhythms” activity on the student CD under Chapter 5 before you proceed to the next section.

Chapter Summary

- Evaluating an ECG requires basic knowledge of the waves, segments, and intervals of the tracing and the rate, rhythm, and regularity of the heartbeat.

- The process of evaluation an ECG tracing includes determining the ECG rhythm or regularity, determining the atrial and ventricular rate, identifying the P wave configuration, measuring the PR interval, and measuring the QRS duration and analyzing the configuration.

- Sinus rhythm is effectively a normal functioning conduction system. Dysrhythmias are abnormal rhythms that indicate a problem with the electrical conduction system, including abnormal rate or regularity.

- Dysrhythmias have varied effects on the patient depending upon their severity. One common problem associated with dysrhythmias is decreased cardiac output. Decreased cardiac is indicated by pale, cool, clammy skin, low blood pressure, and other changes to the neurological, cardiac, respiratory, and urinary systems.

- Each of the dysrhythmias may affect the patient with varying degrees of severity from no changes noted by the patient, to an impending cardiac emergency. When caring for patients, you should be aware of what signs and symptoms to observe and report to your supervisor.

- Electronic or artificial pacemaker's deliver an electrical impulse that paces the atria, ventricles, or both. A pacing spike or artifact on the ECG tracing indicates the stimulation of electrical current from the pacemaker.

- Evaluating a pacemaker ECG tracing includes seven questions; what are the rate and regularity of the paced rhythm, what is the rate and regularity of the patient’s own rhythm, is the atrial lead sensing appropriate, is the atrial capture present, is the AV delay appropriate, is the ventricular sensing appropriate, and is the ventricular capture present?
Chapter Review

Matching:

Match the following terms with their definitions. Place the appropriate letter on the line provided.

1. atrial kick
2. apnea
3. neurological
4. ischemia
5. vagal tone
6. syncope
7. inhibited
8. palpitations
9. supraventricular
10. J point

a. heartbeat sensation felt by the patient
b. electrical current is stopped from being sent to the myocardium
c. pertaining to the nervous system
d. patient loses consciousness
e. impulses on the vagal nerve cause inhibitory effect on the heart
f. an ectopic focus originating above the ventricles
g. point on the QRS complex at which depolarization is complete
h. absence of breathing
i. lack of oxygen to heart muscle cells
j. blood ejected into ventricles prior to ventricular systole

Multiple Choice:

Circle the correct answer.

11. What is the rate of a normal sinus rhythm?
   a. 60 to 100 beats per minute
   b. 50 to 90 beats per minute
   c. 100 to 150 beats per minute
   d. 60 to 80 beats per minute

12. What sinus rhythm has a rate of less than 60 beats per minute?
   a. Sinus tachycardia
   b. Sinus bradycardia
   c. Sinus dysrhythmia
   d. Sinus rhythms
13. Which is not a question that needs to be answered when determining the QRS measurement?
   a. Are all the QRS complexes of equal length?
   b. What is the actual QRS measurement and is it within the normal limits?
   c. Do all QRS complexes look alike and are the unusual QRS complexes associated with an
      ectopic beat?
   d. Is the R-R pattern regular?

14. What sinus rhythm has a rate of more than 100 beats per minute?
   a. Sinus tachycardia
   b. Sinus bradycardia
   c. Sinus dysrhythmia
   d. Sinus rhythms

15. What rhythm shows an irregularity during inspiration and expiration?
   a. Sinus tachycardia
   b. Sinus bradycardia
   c. Sinus dysrhythmia
   d. Sinus rhythms

16. In which period of the cardiac cycle is a strong ventricular stimulus potentially dangerous?
   a. U wave
   b. P wave
   c. T wave
   d. QRS complex

17. The normal PR interval is
   a. 0.04 to 0.10 second.
   b. 0.12 to 0.20 second.
   c. 0.22 to 0.26 second.
   d. 0.28 to 0.32 second.

18. If a QRS complex is wider than 0.12 second, it most likely indicates
   a. normal ventricular conduction.
   b. delayed ventricular conduction.
   c. increased delay at the AV node.
   d. myocardial infarction.

19. What is the range of heart rate for ventricular fibrillation?
   a. 60 to 100 beats per minute
   b. 40 to 60 beats per minute
   c. 100 to 200 beats per minute
   d. Greater than 300 beats per minute

20. What is the normal, inherent rate for the AV junction?
   a. 60 to 100 beats per minute
   b. 40 to 60 beats per minute
   c. 100 to 160 beats per minute
   d. 20 to 40 beats per minute
21. Which of the following dysrhythmias is not considered part of the supraventricular tachycardia classification?
   a. Atrial fibrillation
   b. Sinus tachycardia
   c. Ventricular tachycardia
   d. Junctional tachycardia

22. What sign or symptom might a patient complain about when experiencing a supraventricular tachycardia in an unstable condition?
   a. Back pain
   b. Palpitations
   c. Hypothyroidism
   d. Chest pain and discomfort

23. The criterion needed to classify the dysrhythmia as a supraventricular tachycardia is
   a. a heart rate between 150 and 350 beats per minute.
   b. a wide QRS complex.
   c. a clear, easily identifiable P wave with the entire wave visualized.
   d. atrial and ventricular rates that are not the same.

24. What is the primary difficulty in determining a supraventricular rhythm?
   a. Determining the ventricular rate
   b. Determining the regularity
   c. Measuring the QRS interval
   d. Determining the origin of the tachycardia

25. When is the identification of the specific dysrhythmia important in terms of treatment of the patient?
   a. When the patient first complains of any signs or symptoms
   b. When the patient's heart rate has decreased to a rate of 100 to 150 beats per minute
   c. During the treatment of a fast tachycardia situation
   d. After the rhythm has been converted to a normal rhythm and/or the heart rate is between 60 and 100 beats per minute

26. You observe a wide QRS complex while continuously monitoring a patient in lead II. Which lead placement is necessary to evaluate the location of blockage in the bundle branch system?
   a. Lead I
   b. Lead V4
   c. Lead III
   d. Lead VI

27. The labeling of the ECG rhythm strip for documentation of the bundle branch block should include what other information besides which bundle is being blocked?
   a. Symptoms the patient is experiencing
   b. Blood pressure reading
   c. Presence of an MI diagnosis
   d. Patient's inherent rhythm pattern

28. What is the minimum QRS measurement for a ventricular complex?
   a. 0.06 to 0.10 second
   b. 0.04 to 0.08 second
   c. Less than 0.12 second
   d. Greater than 0.12 second
29. What do you call two PVCs that are connected to each other without a normal beat in between?
   a. Coupling or pair
   b. Run of ventricular tachycardia
   c. Frequent PVCs
   d. R-on-T PVCs

30. Which of the following is not one of the components to be evaluated on a pacemaker tracing?
   a. The presence of atrial and/or ventricular spikes
   b. The QT interval
   c. The characteristic patterns of the chambers captured after the spikes
   d. The atrioventricular delay period

### Matching II

Match the following terms related to electronic (artificial) pacemakers to their definitions.

- ______ 31. pacemaker competition
- ______ 32. pacemaker (electronic)
- ______ 33. loss of capture
- ______ 34. malsensing
- ______ 35. malfunctioning
- ______ 36. oversensing
- ______ 37. triggered
- ______ 38. capture

a. electrical current causes the myocardial tissue to depolarize (contract)
b. heart muscle responds to electrical stimulation and depolarizes (contracts)
c. device that delivers electrical energy to cause depolarization (contractions)
d. pacing activity occurs but is not captured by the myocardium
e. pacemaker does not recognize the patient's inherent heart rate
f. electrical current from muscle movements or other activities are sensed by the pacemaker
g. pacemaker fails to send electrical impulse to the heart
h. patient's own heart and the electronic pacemaker compete over electrical control of the heart

### What Should You Do? Critical Thinking Application

Read the following situations and use your critical thinking skills to determine how you would handle each. Write your answer in detail in the space provided.

39. When performing an ECG on Mr. Bobela, you notice chaotic electrical activity on the ECG tracing. Mr. Bobela was awake when you started the ECG and is lying quietly now. What should you do?
40. Ms. Gomez has a second degree AV block, Mobitz I rhythm. Mrs. Jenwren has a second degree AV block, Mobitz II. Which patient has a more serious condition? Explain your answer.

41. The rhythm on the ECG machine is ventricular tachycardia. What information would you need to know about the patient in order for proper treatment to begin?

42. You noticed that Mr. Green is having a wide QRS complex on the monitor. The continuous monitoring equipment has only three lead wires. How would you describe the type of block the patient is experiencing when notifying the physician of the change?

43. Mrs. Estes, an inpatient in your facility, has just finished shopping on the TV shopping network and knows that she has spent too much money. She is complaining that she is having palpitations. You notice that the heart rate is fast and her rhythm indicates an SVT pattern. What should you find out about the patient prior to notifying the licensed practitioner of the rapid heartbeat?

**Rhythm Identification**

Review the dysrhythmias pictured here and, using the criteria for classification provided in the chapter as clues, identify each rhythm and provide what information you used to make your decision.

44. Rhythm: ____________________________

   Clues: ______________________________

   ______________________________

   ______________________________
45. Rhythm: ____________________________
   Clues: ______________________________
       ________________________________
       ________________________________

46. Rhythm: ____________________________
   Clues: ______________________________
       ________________________________
       ________________________________

47. Rhythm: ____________________________
   Clues: ______________________________
       ________________________________
       ________________________________
48. 
Rhythm: _____________________________
Clues: ________________________________

49. 
Rhythm: _____________________________
Clues: ________________________________

50. 
Rhythm: _____________________________
Clues: ________________________________
51. 
Rhythm: ________________________________
Clues: __________________________________

52. 
Rhythm: __________________________________
Clues: __________________________________

53. 
Rhythm: __________________________________
Clues: __________________________________
54. **Rhythm:**

**Clues:**

---

55. **Rhythm:**

**Clues:**

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56. **Rhythm:**

**Clues:**

---
Perform a complete analysis of the following rhythms completing all the information in the blanks provided.

60.

Rhythm: ______________________  Rate: ______________________
P wave: ______________________  PRI: ______________________
QRS Complex: ______________________  Interpretation: ______________________

61.

Rhythm: ______________________  Rate: ______________________
P wave: ______________________  PRI: ______________________
QRS Complex: ______________________  Interpretation: ______________________

62.

Rhythm: ______________________  Rate: ______________________
P wave: ______________________  PRI: ______________________
QRS Complex: ______________________  Interpretation: ______________________
63. 

Rhythm: ______________________ Rate: ______________________

P wave: ______________________ PRI: ______________________

QRS Complex: ______________________ Interpretation: ______________________

64. 

Rhythm: ______________________ Rate: ______________________

P wave: ______________________ PRI: ______________________

QRS Complex: ______________________ Interpretation: ______________________

65. 

Rhythm: ______________________ Rate: ______________________

P wave: ______________________ PRI: ______________________

QRS Complex: ______________________ Interpretation: ______________________
<table>
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<tr>
<th>Rhythm:</th>
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<th>P wave:</th>
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</table>
69. Rhythm: ______________________  Rate: ______________________
P wave: ______________________  PRI: ______________________
QRS Complex: _________________  Interpretation: _________________

70. Rhythm: ______________________  Rate: ______________________
P wave: ______________________  PRI: ______________________
QRS Complex: _________________  Interpretation: _________________

71. Rhythm: ______________________  Rate: ______________________
P wave: ______________________  PRI: ______________________
QRS Complex: _________________  Interpretation: _________________
72.

Rhythm: ___________________________  Rate: ___________________________

P wave: ___________________________  PRI: ___________________________

QRS Complex: ___________________________  Interpretation: ___________________________

73.

Rhythm: ___________________________  Rate: ___________________________

P wave: ___________________________  PRI: ___________________________

QRS Complex: ___________________________  Interpretation: ___________________________

74.

Rhythm: ___________________________  Rate: ___________________________

P wave: ___________________________  PRI: ___________________________

QRS Complex: ___________________________  Interpretation: ___________________________

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75. Rhythm: ___________________________ Rate: ___________________________
   P wave: ___________________________ PRI: ___________________________
   QRS Complex: ______________________ Interpretation: ____________________

76. Rhythm: ___________________________ Rate: ___________________________
   P wave: ___________________________ PRI: ___________________________
   QRS Complex: ______________________ Interpretation: ____________________

77. Rhythm: ___________________________ Rate: ___________________________
   P wave: ___________________________ PRI: ___________________________
   QRS Complex: ______________________ Interpretation: ____________________
78. 

Rhythm: ______________________  Rate: ______________________

P wave: ______________________  PRI: ______________________

QRS Complex: __________________ Interpretation: __________________

79. 

Rhythm: ______________________  Rate: ______________________

P wave: ______________________  PRI: ______________________

QRS Complex: __________________ Interpretation: __________________

80. 

Rhythm: ______________________  Rate: ______________________

P wave: ______________________  PRI: ______________________

QRS Complex: __________________ Interpretation: __________________
81. 

Rhythm: __________________________  Rate: __________________________
P wave: ________________  PRI: __________________________
QRS Complex: ________________  Interpretation: __________________________

82. 

Rhythm: __________________________  Rate: __________________________
P wave: ________________  PRI: __________________________
QRS Complex: ________________  Interpretation: __________________________

83. 

Rhythm: __________________________  Rate: __________________________
P wave: ________________  PRI: __________________________
QRS Complex: ________________  Interpretation: __________________________
Get Connected Internet Activity

Visit the McGraw-Hill Higher Education Online Learning Center Electrocardiography for Health Care Personnel Web site at www.mhhe.com/healthcareskills to complete the following activity.

1. The Alan E. Lindsay ECG Learning Center in Cyberspace is an excellent resource for more ECG learning and practice. Visit this link from the Online Learning Center and review images of rhythms, then test your knowledge. Challenge yourself and then print your scores for your instructor.

2. The 12-Lead ECG Library is also a useful site for reviewing ECGs. Go to this site from the Online Learning Center and practice before completing the rhythm identification section of this chapter.

Using the Student CD

Now that you have completed the material in the chapter text, return to the student CD and complete any chapter activities you have not yet done. Practice your terminology with the “Key Term Concentration” game. Review the chapter material with the “Spin the Wheel” game. Take the final chapter test and complete the troubleshooting question and email or print your results to document your proficiency for this chapter.