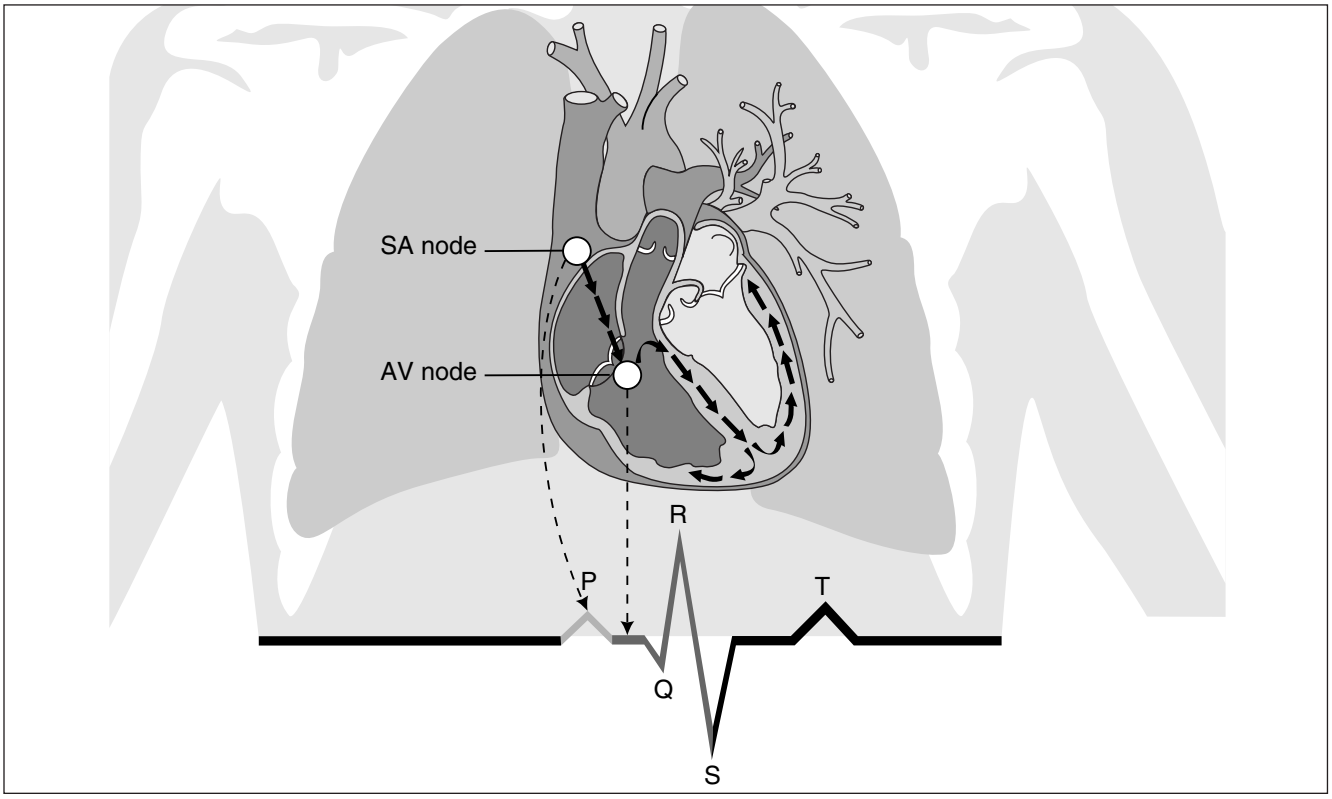
ECG Rhythms



An electrocardiogram (ECG) is a record of the electrical activity in the heart. Electrical impulses are shown as a series of distinct waves in repeating cycles.

The ***P-wave*** represents atrial depolarization and contraction. The ***QRS complex*** represents ventricular depolarization and contraction. The ***T-wave*** represents ventricular repolarization and relaxation.*

An ECG is recorded from the body's surface, using an electrocardiograph. It is used to determine if the heart's electrical activity is normal or abnormal.

* Atrial repolarization waves are small and occur during ventricular depolarization (QRS complex), so they are usually not seen on an ECG.

Notes

An ECG is a graphic representation of the heart's electrical activity.

Questions:

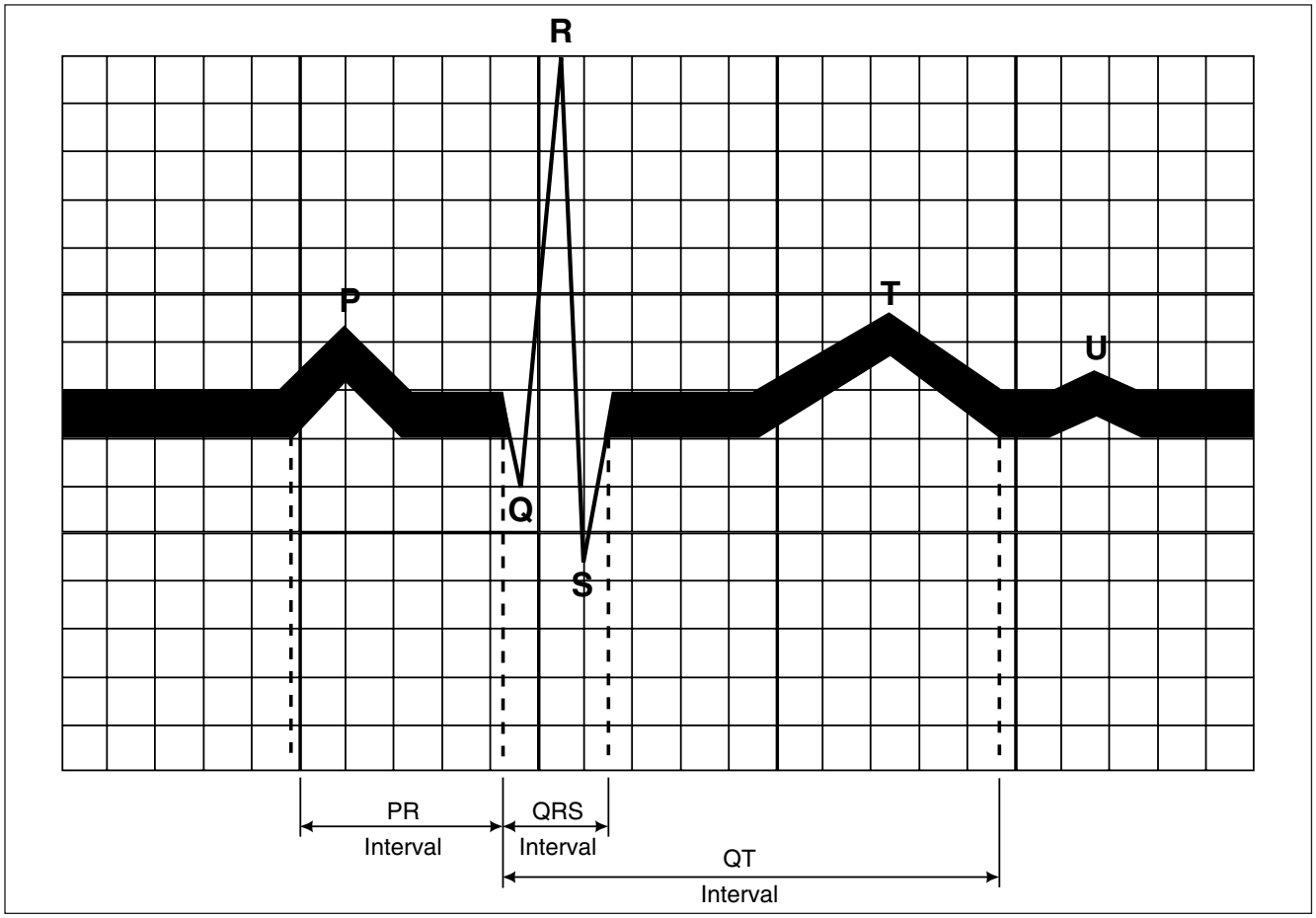
Atrial depolarization is represented by a _____.

Ventricular depolarization is represented by a _____.

Ventricular repolarization is represented by a _____.

Answers: P-wave / QRS complex / T-wave

Intervals



Intervals (or measures of time) are shown on the horizontal axis of the ECG.

The ***PR interval*** is the time from the beginning of atrial depolarization to the beginning of ventricular depolarization. The ***QRS interval*** is the time it takes for the ventricles to depolarize. The ***QT interval*** includes the QRS and ST intervals, which is the time it takes for the ventricles to depolarize and recover.

The length of an interval is determined by the rate of depolarization.

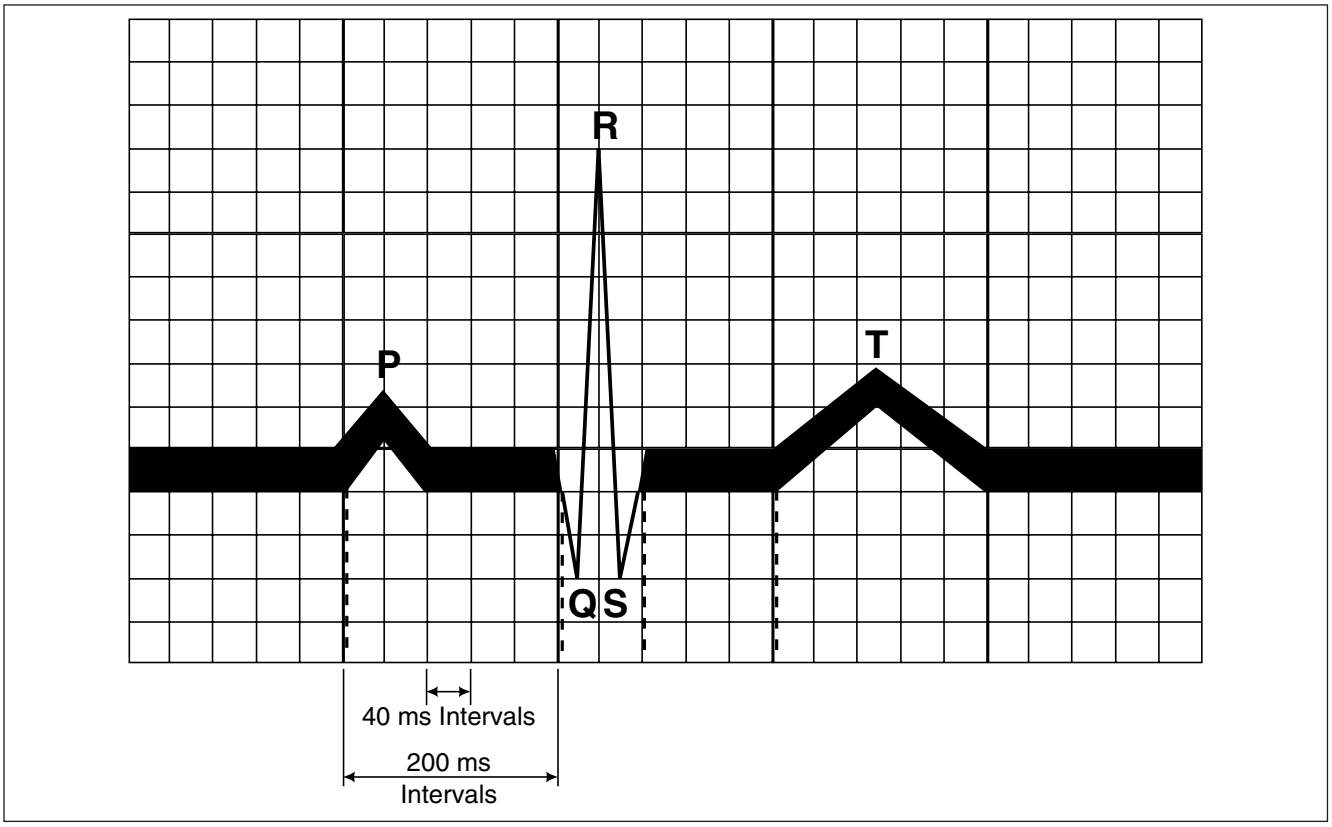
Notes

Question:

The segments of an ECG waveform that depict time are called _____.

Answer: intervals

Interval Measurement



The ECG is recorded on ruled graph paper. The length of each small box represents 40 milliseconds (ms) of time. There are five boxes between the heavy black lines, so this distance represents 200 milliseconds (40 ms x 5 boxes).

The normal duration of a PR interval is 120-200 ms (3-5 small boxes) while the normal duration of a QRS complex is 60-120 ms (1.5-3 small boxes).

Heart rate can be determined by a simple mathematical formula. The number of milliseconds in a minute (60,000) is divided by the number of beats per minute (bpm). This formula can also be reversed as shown below.

$$\frac{60{,}000}{\text{BPM}} = \text{ms} \quad \text{or} \quad \frac{60{,}000}{\text{ms}} = \text{BPM}$$

If rate is 60 bpm...

$$\frac{60{,}000}{60\ \text{bpm}} = 1{,}000\ \text{ms (interval)}$$

Notes

Questions:

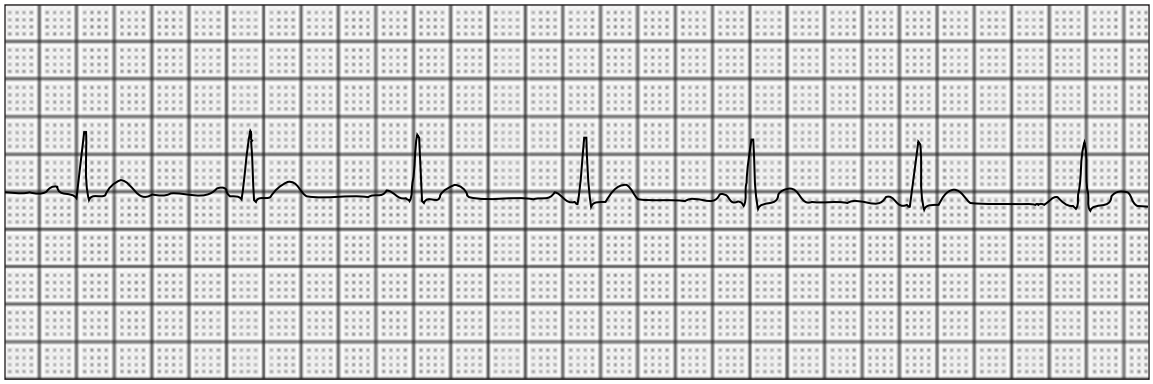
The length of the PR interval above is _____ (ms).

The length of the QRS interval above is _____ (ms).

The length of time from beginning to end of the graph paper shown above is _____ (ms).

Answers: 200 / 80 / 1,000

Normal Sinus Rhythm



In a normal sinus rhythm, electrical impulses originate at the sinoatrial node and occur at regular intervals. The ECG shows an equal distance between similar waveforms.

The ***sinus rhythm*** is the rate set by the sinoatrial (or sinus) node. The normal rate in an adult at rest is 60-100 beats per minute (bpm). In children, it is 100-120 bpm. The heart rate increases normally with exercise and decreases as exercise ends.

In some individuals, the normal resting rate lowers during sleep or is generally lower. Some athletes, for example, have a lower normal rate because the heart has been conditioned to pump sufficient blood with fewer heartbeats.

Note: Copy this page and use it for comparison as you study the abnormal rhythms (arrhythmias) described on the following pages.

Notes

A normal sinus rhythm occurs when electrical impulses start at the sinus node and discharge at a normal rate – usually 60-100 bpm in a resting adult.

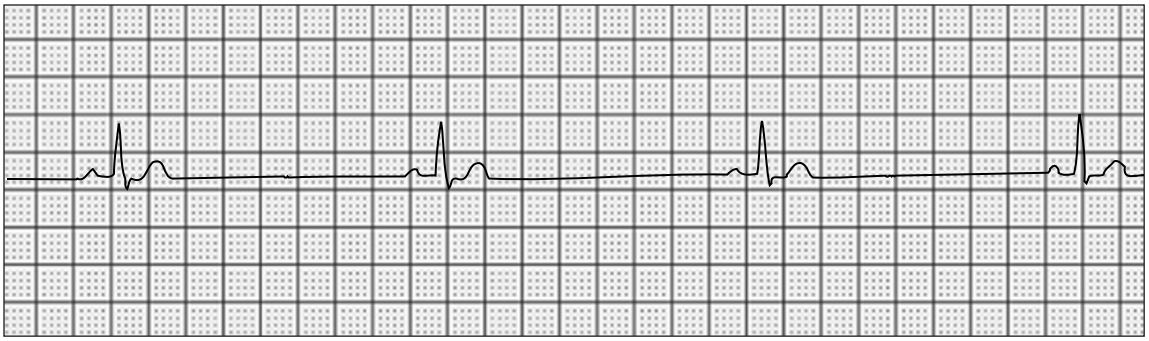
Question:

The heart rate set by the sinoatrial node is the _____.

Answer: sinus rhythm

Abnormal Sinus Rhythms

Sinus Bradycardia



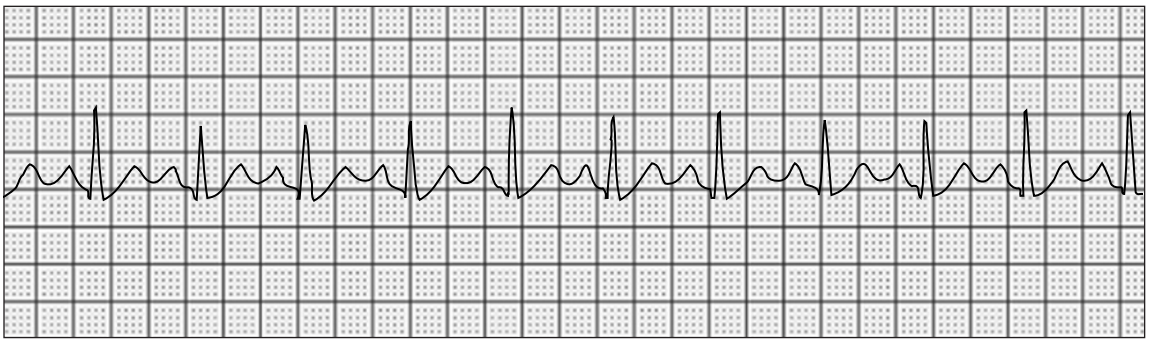
In ***sinus bradycardia***, the sinus rate is slower than normal – usually 40-60 bpm in a resting adult. The ECG shows a wide separation of impulses, but the impulse itself is normal.

Question:

A wide separation of normal waves indicates _____.

Answer: sinus bradycardia

Sinus Tachycardia



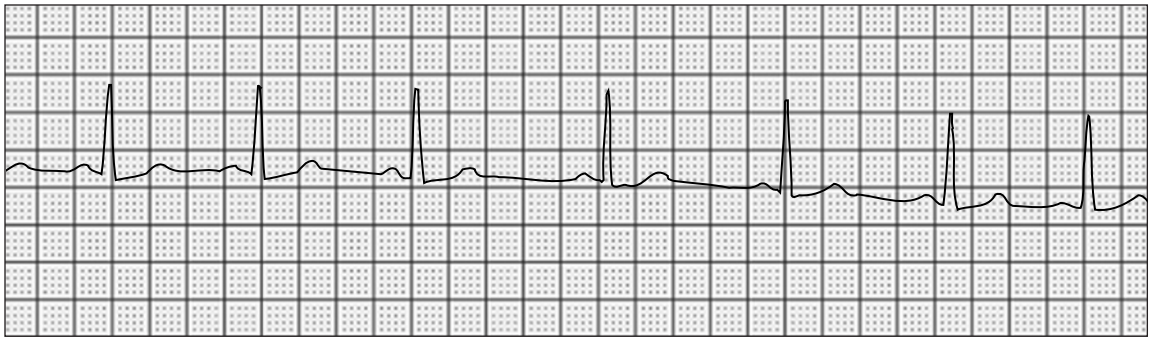
In ***sinus tachycardia***, the sinus rate is faster than normal – usually 100-160 bpm. The ECG shows a narrow separation of normal impulses.

Question:

A narrow separation of normal waves indicates _____.

Answer: sinus tachycardia

Sinus Arrhythmia



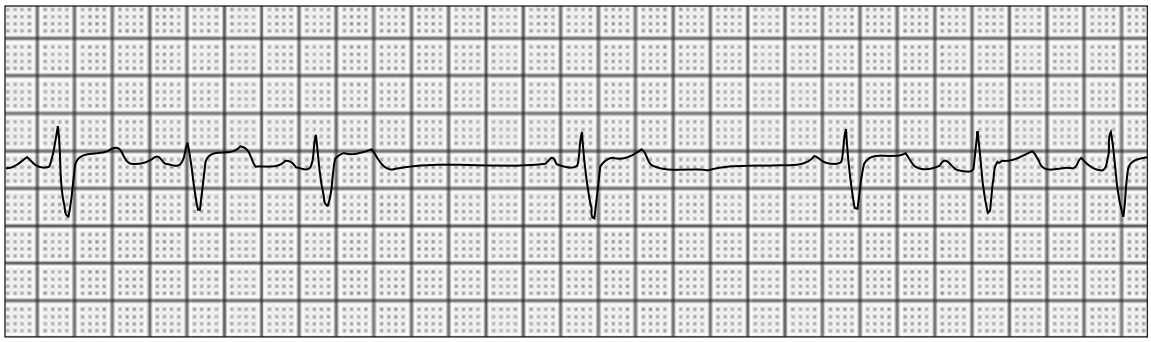
In ***sinus arrhythmia***, electrical impulses are discharged from the sinus node at varying rates. The ECG shows normal impulses at irregular intervals. The heart rate may be normal (60-100 bpm) or slow (less than 60 bpm).

Question:

An irregular rhythm (fast and slow) of normal impulses indicates _____.

Answer: sinus arrhythmia

Sinus Block



In ***sinus block***, an electrical impulse is blocked as it exits the sinus node, preventing conduction.* After the delay, the underlying rhythm resumes on time. The ECG shows an occasional long pause between normal impulses.

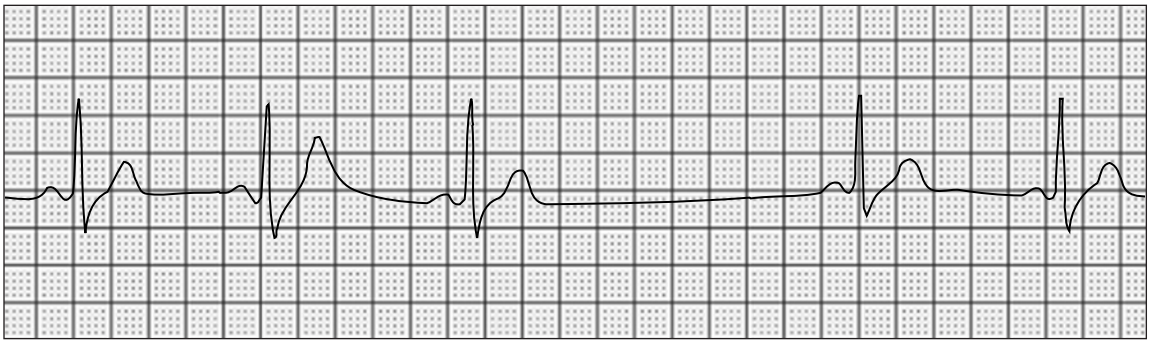
* Heart block is a condition in which the electrical signal is delayed or stopped somewhere in the conduction system. Block can occur at the sinoatrial node, atrioventricular node, or bundle branches of the ventricle. A slight or intermittent block produces abnormal delays in conduction. Complete block produces abnormal conduction or conduction failure.

Question:

A long pause between normal impulses indicates _____.

Answer: sinus block

Sinus Arrest



In ***sinus arrest***, the sinoatrial node fails to initiate electrical impulses. This results in long delays between electrical impulses on an ECG. A long pause may induce an electrical response from ectopic foci.*

* There are areas of the heart - called ***ectopic foci*** - that can initiate and maintain electrical impulses in emergency situations. If the sinoatrial node is completely blocked, for example, ectopic foci in the atria assume pacing responsibility. Ectopic foci are also available at the atrioventricular node and in the ventricles. The beat produced by an ectopic focus is called an escape beat, and the rhythm produced by escape beats is called an escape rhythm.

Question:

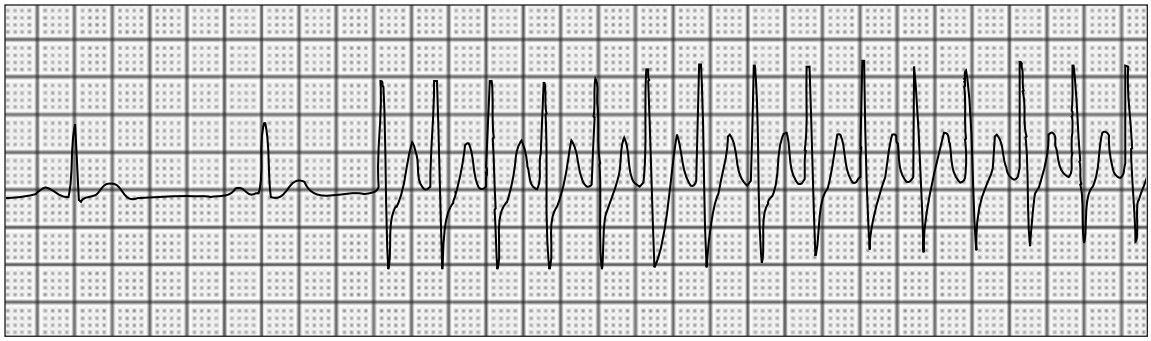
A long, flat line between normal impulses indicates a period of _____.

Backup emergency pacing is provided by _____.

Answers: sinus arrest / ectopic foci

Abnormal Atrial Rhythms

Atrial Tachycardia



In ***atrial tachycardia***, electrical impulses originate at ectopic sites in the atria and travel through a reenty circuit near the atrioventricular node. On the ECG, P-waves are difficult to see and the QRS complex is narrow. The rhythm is regular and the atrial rate is between 140 to 250 bpm.

Question:

A normal wave sequence with obscured P-waves indicates _____.

Answer: atrial tachycardia

Atrial Flutter

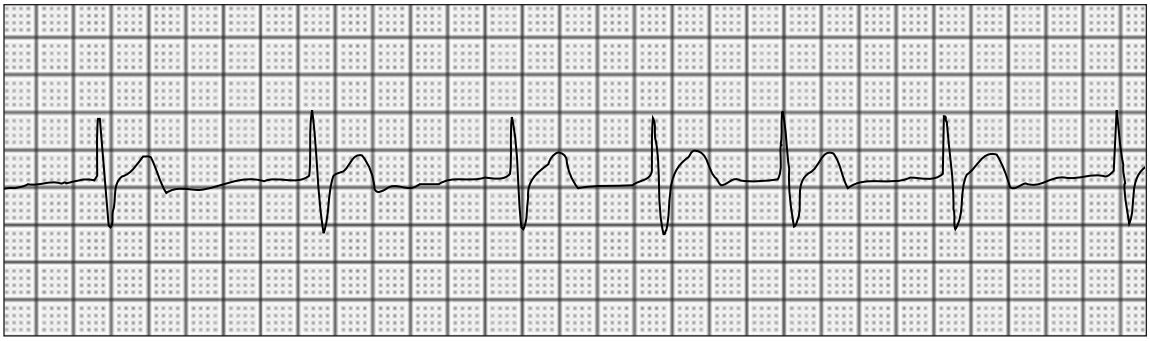
In ***atrial flutter***, electrical impulses arise from atrial ectopic sites, producing atrial rates of 250 to 400 bpm. The ventricular rate varies with conduction. On the ECG, identical P-waves (called flutter waves) occur in close succession between normal QRS complexes. This gives the waveform a sawtooth appearance.

Question:

Many flutter waves between normal QRS complexes indicate _____.

Answer: atrial flutter

Atrial Fibrillation



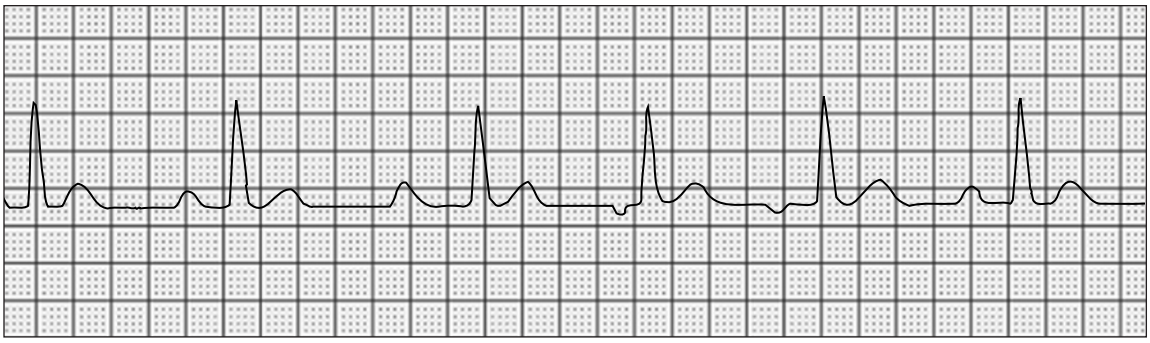
Atrial fibrillation is due to the rapid discharge of ectopic beats from multiple sites in the atria. The atrial rate may be 400 bpm or more. The ventricular rate varies with conduction, but is always slower than the atrial rate. The ventricular rhythm is grossly irregular. The ECG shows irregular wavy deflections instead of normal P-waves.

Question:

A wavy baseline with irregular QRS complexes indicates _____.

Answer: atrial fibrillation

Wandering Atrial Pacemaker



Wandering atrial pacemaker occurs when electrical impulses originate from varying sites in the atria. The atrial rate is normal – usually 60-100 bpm, but there is variation in the size and shape of P-waves.

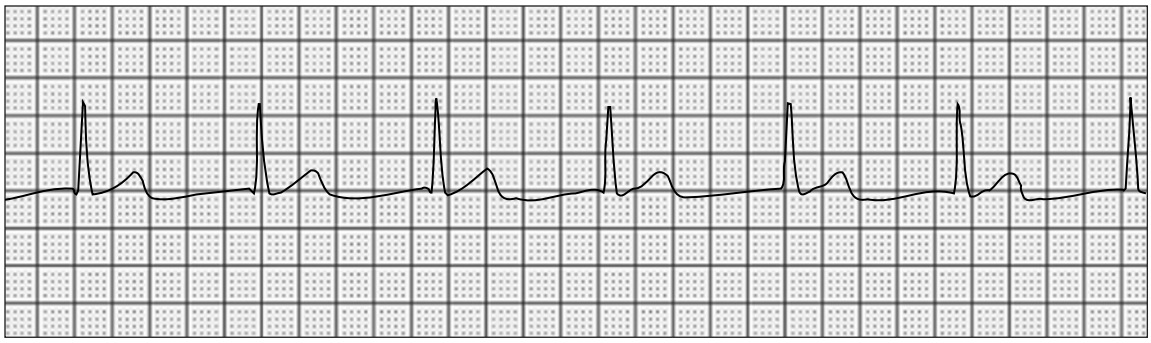
Question:

An irregular rhythm with P-waves of various shapes indicates _____.

Answer: wandering atrial pacemaker

Abnormal Atrioventricular (AV) Node Rhythms

Junctional Rhythm



In a ***junctional rhythm***, electrical impulses originate in the atrioventricular node. Junctional rates are usually slow – 40 to 60 bpm – but regular. The ECG shows normal QRS complexes and inverted P-waves. P-waves may immediately precede, follow, or be hidden within the QRS complex.

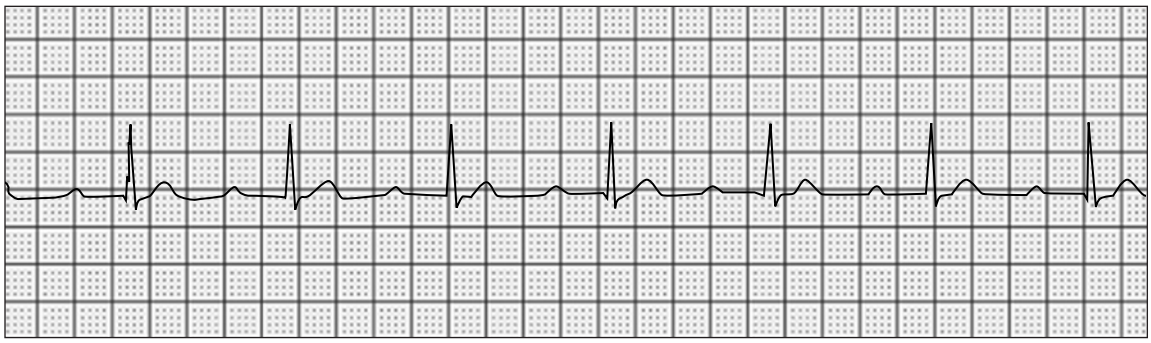
Note: Junctional rhythms may be accelerated to rates between 60 and 100 bpm or rapid with rates over 100 bpm (called *junctional tachycardia*). If retrograde P-waves are hidden in the QRS complex, it may be difficult to distinguish between junctional tachycardia and atrial tachycardia.

Question:

An obscured P-wave (sometimes inverted) with normal QRS complexes indicates a _____.

Answer: junctional rhythm

First-Degree AV Block



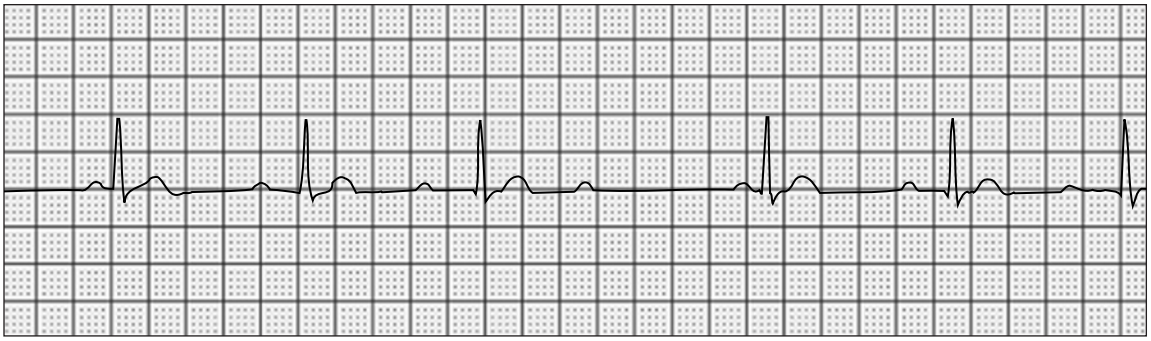
In ***first-degree atrioventricular block***, there is a slight delay in the conduction of a normal impulse from the atria to the ventricles. The ECG shows prolonged PR intervals (7200 ms), but a normal cycle of depolarization waves. Rates are normal.

Question:

A prolonged PR interval in a regular sequence indicates _____.

Answer: first-degree AV block

Second-Degree AV Block, Type I



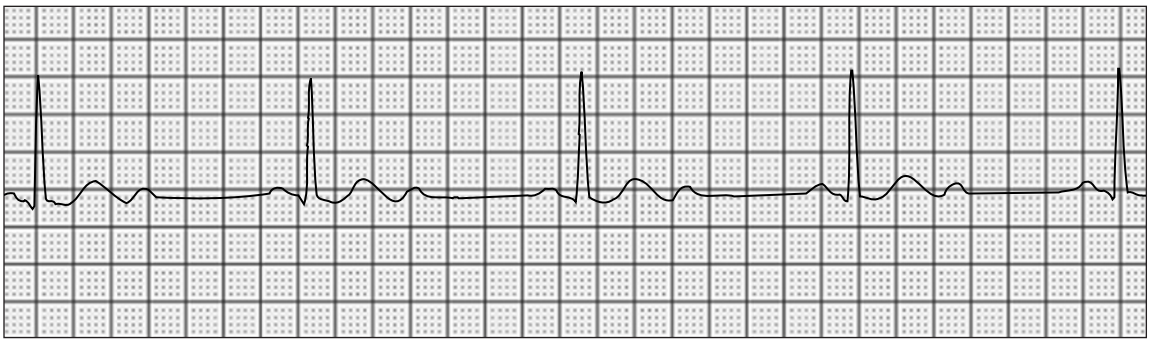
In ***second-degree atrioventricular block, Type I*** (called Wenckebach block), there is an intermittent delay in the conduction of normal sinus impulses from the atria to the ventricles. The PR interval becomes progressively longer until the QRS complex fails to appear. The sequence is then repeated. Typically, the sequence is three P-waves for every two QRS complexes - a conduction ratio of 3:2. Rates are usually slower than normal.

Question:

Progressively longer PR intervals with intermittent dropped QRS complexes indicate _____.

Answer: second-degree AV block, Type I

Second-Degree AV Block, Type II



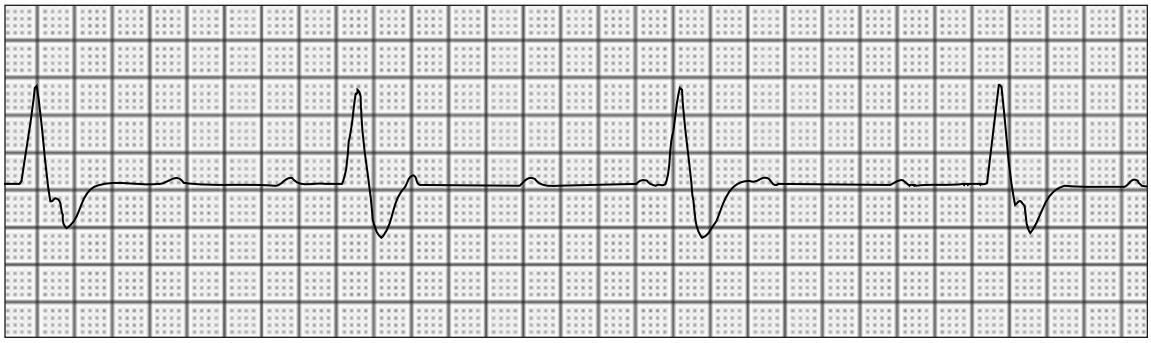
In ***second-degree atrioventricular block, Type II*** (called Mobitz II block), normal sinus impulses are regularly prevented from reaching the ventricles. The ECG shows occasional dropped QRS complexes without lengthening of the PR interval. Conduction ratios are poor – 3:1, 4:1, or worse. Rates are usually slower than normal.

Question:

Normal PR intervals with sudden dropped QRS complexes indicate _____.

Answer: second-degree AV block, Type II

Third-Degree AV Block



In ***third-degree atrioventricular block***, no sinus impulses reach the ventricles. The atria are stimulated by the sinus node, and the ventricles by ectopic foci. The ECG shows no relationship between P-waves and QRS complexes (they are dissociated). The atrial rate is normal, but the ventricular rate is slow - usually less than 40 bpm. The QRS complex is abnormally wide.

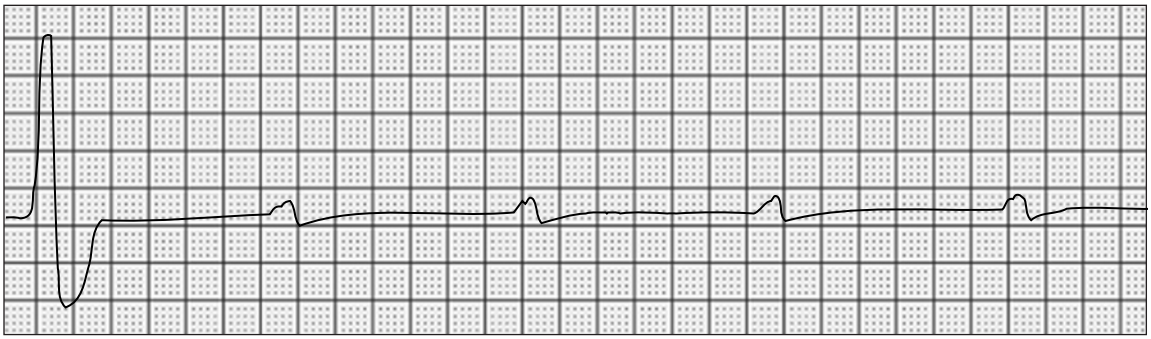
Question:

Complete dissociation between P-waves and QRS complexes indicates _____.

Answer: third-degree AV block

Abnormal Ventricular Rhythms

Primary Ventricular Standstill



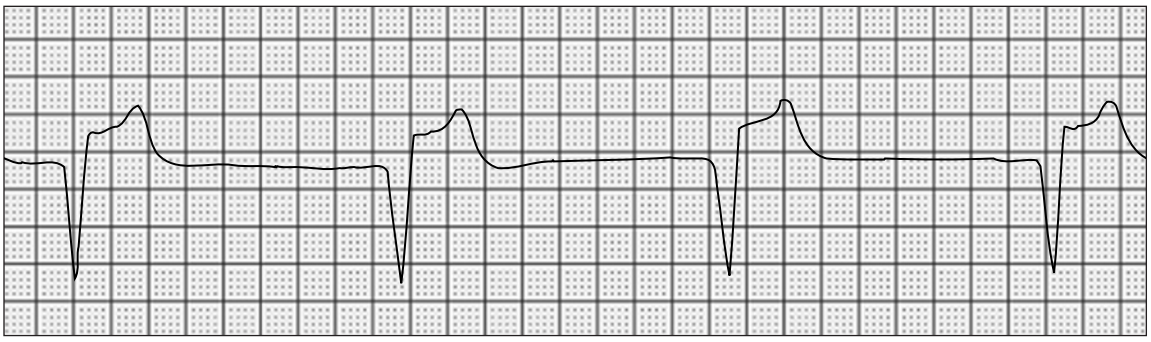
In ***primary ventricular standstill***, sinus impulses do not reach the ventricles nor are the ventricles stimulated by ectopic foci. The ECG shows normal P-waves at regular intervals. The QRS complex is absent, so PR intervals cannot be measured.

Question:

Normal P-waves with no QRS complexes indicate _____.

Answer: primary ventricular standstill

Idioventricular Rhythm



An ***idioventricular rhythm*** occurs when ectopic foci located at or above the atrioventricular node fail to discharge. The ECG shows wide QRS complexes, but no P-waves. Idioventricular rates are very slow – usually 30-40 bpm.

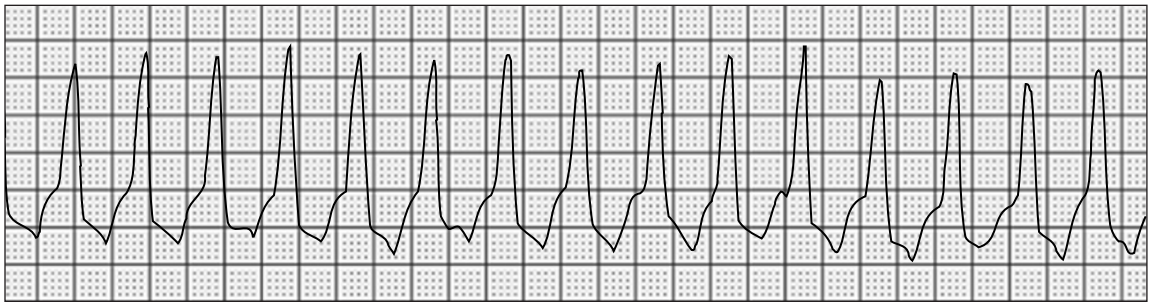
Note: Idioventricular rhythms may be accelerated to rates of 50-100 bpm. A fast idioventricular rhythm has the same shape as a slow one: wide QRS complexes and no P-waves.

Question:

Wide QRS complexes with no P-waves indicate an _____.

Answer: idioventricular rhythm

Ventricular Tachycardia



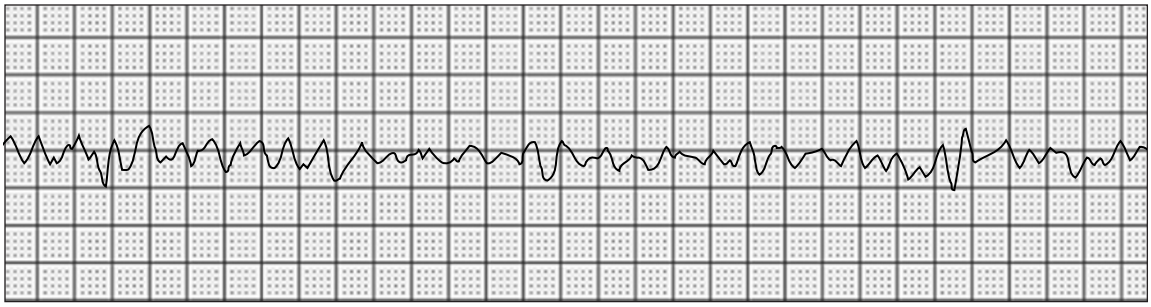
Ventricular tachycardia arises from an ectopic pacemaker site in the ventricles discharging impulses at a rate of 140 to 250 bpm. QRS complexes are wide and poorly shaped, and there are no related P-waves. Rates range from 120-140 bpm.

Question:

Wide and oddly-shaped QRS complexes with no related P-waves indicate _____.

Answer: ventricular tachycardia

Ventricular Fibrillation



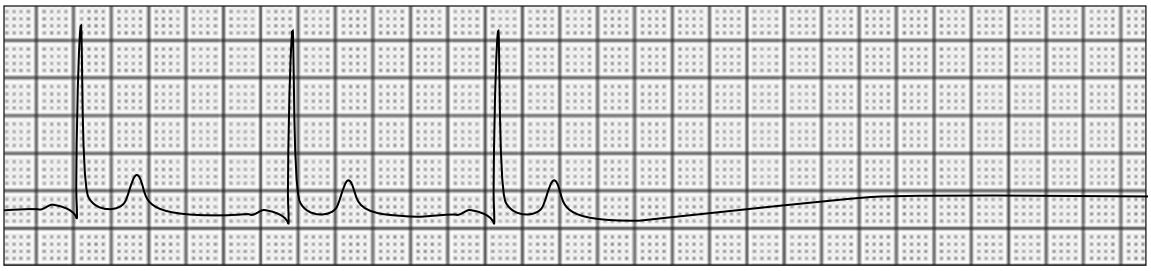
In ***ventricular fibrillation,*** rates are so rapid that the ventricles twitch in a disorganized and chaotic manner. The ECG shows no identifiable waves and no pattern of impulses.

Question:

Erratic waves with no identifiable shape indicate _____.

Answer: ventricular fibrillation

Asystole



In ***asystole,*** there is no electrical activity in the heart and the ECG shows a flat line.

Question:

No electrical activity is _____.

Answer: asystole

Bundle Branch Block

In ***bundle branch block,*** conduction of impulses is delayed or blocked in the left or right bundle branch. The blocked side is stimulated by impulses that reach the unblocked side. The ECG shows a wide QRS complex with two R-waves. P-waves are normal and so is the rate of depolarization.

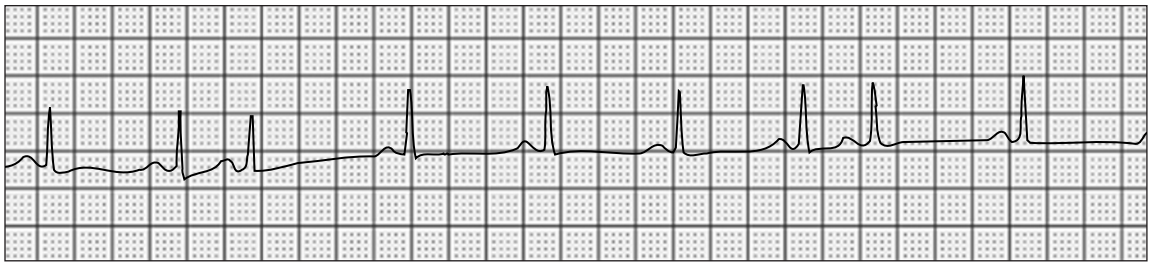
Question:

Two R-waves in a wide QRS complex indicate _____.

Answer: bundle branch block

Unusual Beats

Premature Atrial Contraction



A ***premature atrial contraction (PAC)*** is due to the sudden discharge of an atrial ectopic focus. It appears as an extra complex on a normal ECG waveform. The extra P-wave may have an unusual shape, and the extra QRS complex may be narrower than usual. Rates are typically normal.

In ***nonconducted premature atrial contractions***, premature atrial ectopic beats are not conducted to the ventricles. The extra P-wave is followed by a pause instead of an extra QRS complex. Rates are typically normal.

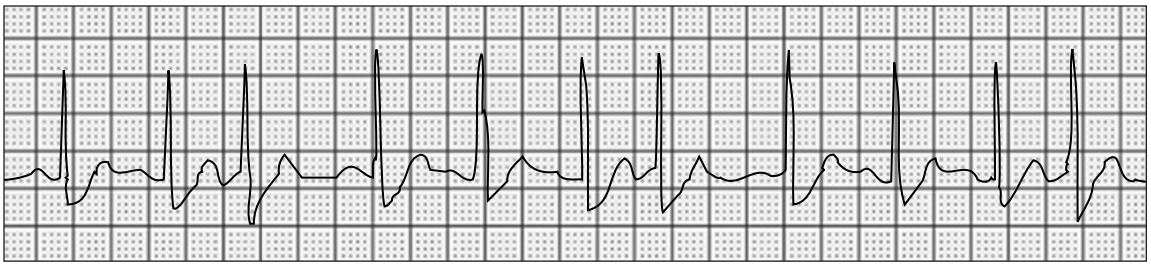
Questions:

An extra P-wave and QRS complex in a normal waveform indicates a _____.

An extra P-wave in a normal waveform indicates _____.

Answers: premature atrial contraction / nonconducted premature atrial contraction

Premature Junctional Contraction



In ***premature junctional contractions***, the extra ectopic beat originates in the atrioventricular node. The extra P-wave may immediately precede, follow, or be hidden within the QRS complex and is often inverted. Rates are typically normal.

Question:

An early ectopic beat with a P-wave (often inverted) that immediately precedes, follows, or is hidden in the QRS complex indicates _____.

Answer: premature junctional contraction

Premature Ventricular Contraction

Premature ventricular contractions (PVCs) are due to premature ectopic beats that originate in the ventricles. The QRS is wider than normal, and P-waves are usually hidden. The heart rate varies.

Question:

An early, wide QRS complex without an associated P-wave indicates a _____.

Answer: premature ventricular contraction