flip and see E.C.G.

3rd Edition

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This book is dedicated to:

Bruce Cohn, who is the love of my life and has given me a life that I love.

Beatrice, Ronald, and Peter Gross and Zachary and Michelle Cohn. I have been blessed with an incredible family. They inspire me with their brilliant thoughts and endless love.

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This book is humbly dedicated to Willem Einthoven, inventor of the electrocardiograph machine.

For hundreds of years, the only known method for observing the beating of the heart was by opening the chest, breaking the sternum in half, and having a look. Sadly, the patients usually died. The discovery that the movements of muscles are regulated by electrical current began in 1664, when Jan Swammerdam removed the heart of a living frog but showed it was still able to swim. When the frog was dissected and the nerve endings were stimulated with a scalpel, the muscles twitched – refuting the theory that “animal spirits” controlled muscles.

In the years that followed, through brilliant scientific work, careful observations, and some random chance, it was discovered that the electrical impulses controlled muscle movements. The recording of this electrical activity became the basis for the ECG.

In 1887, Augustus Waller invented the electrode. This electrode allowed the electrical currents to be measured through intact skin, which was a tremendous boon to both patients and medical personnel. The electrode was a large magnetic plate that hooked up to a capillary electrometer, a column of mercury that rose and fell with changes in the electrical field. This elegant invention had advantages and disadvantages. The advantage was in not having to cut the patient open to expose the heart. The disadvantage was the long lag time between the action of the heart and the action of the mercury. Moreover, you needed to perform a complex mathematical calculation to establish a heart pattern. By the time the measurement was finished, so was the patient.

Willem Einthoven is credited with the invention of the electrocardiograph machine, and for this, he was awarded the Nobel Prize. The electrocardiogram, the graphic representation of electrical activity, is also known as the EKG or ECG (“electrokardiogramm” from the German, abbreviated EKG). The medical profession currently uses these abbreviations interchangeably.

Einthoven’s ECG machine was a fine quartz wire suspended in a magnetic field. When subjected to an electrical current, the wire deflected according to the charge. This motion was magnified and photographed on a moving reel of film. Because it was very light in weight, the wire responded almost instantaneously to any changes in the electrical current. Einthoven established the criteria for normal ECGs and named the waves P, QRS, and T. He further designated the three points on the body where the electrodes should be placed.

Today the ECG machine remains one of the most important tools in medicine used for diagnosis, monitoring, gauging response to therapy, and recording past events. We rely on ECGs daily in ambulances and hospitals to save the lives of thousands.

**PHYSICAL EXAMINATION**

**Obtaining a Patient History**

A complete and accurate picture of the patient can be obtained when you use an organized approach to patient history and physical examination. Experienced clinicians start their assessment with how the patient looks. They ask if there is a past cardiac history. There are more than 30 differential diagnoses for the chest pain patient. The beginning practitioner should be aware that *acute myocardial infarction*, or heart attack, is among the most critical of the chest pain scenarios. However, all chest pain should be taken seriously and treated as cardiac until proven otherwise.

**SAMPLER System**

The SAMPLER system assists practitioners in a quick and accurate assessment. In the *SAMPLER* system, the patient is asked about:

- **Signs and Symptoms** — specifically related to chest pain or chest pressure such as the time of onset, radiation of the chest pain, was it relieved with nitroglycerin, is it associated with shortness of breath? See OPQRST-I system (next section).
- **Allergies** — especially to medications, shellfish, or iodine.
- **Medications** — especially cardiac medications, antihypertensive drugs, antiarrhythmics, and insulin.
- **Past history** — anyone with a history of a cardiac condition and current chest pain is considered to be a cardiac patient.
- **Last meal** — necessary information for anesthesia.
- **Events leading to this episode of chest pain**, it is especially noteworthy if the pain woke the patient from sleep or continued even when the patient was at rest.
- **Risk factors** — smoking, diabetes, hypertension, coronary artery disease, high cholesterol, or a family history of heart disease.

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*Angina, acute myocardial infarction, bronchitis, cardiogenic shock, cardiac tamponade, aortic dissection, leaking aortic aneurysm, mitral valve prolapse, aortic stenosis, aortic insufficiency, pericarditis, pericardial effusion, pleurisy, pleural effusion, pneumothorax, pneumomediastinum, pulmonary hypertension, pulmonary embolism, pneumonia, tumors, esophagitis, esophageal spasm, hiatal hernia, gastritis, perforated duodenal ulcer, pancreatitis, cholecystitis, musculoskeletal disorders, rib fractures, and costochondritis, to name some.

†For a complete and up-to-date list of modifiable and non-modifiable risk factors, please contact the American Heart Association in your area.
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OPQRST-I System
The OPQRST-I system helps patients to describe chest pain:

Onset: What were you doing when the pain started?

Provokes: What makes the pain worse, or better? Does it increase with movement?
Stop when you rest? Can you take a deep breath?

Quality: What kind of pain? Is it sharp and stabbing or dull? Does it feel like pressure?
Is it intermittent—does it come and go?

Radiates: Does it go anywhere? Jaw? Left arm?

Severity: Rate the pain/pressure on a scale of 1–10, with 1 being very little pain
and 10 being very severe. (This is used diagnostically and to gauge efficacy of
treatment.)

Time: How long have you had the pain? (In cardiac chest pain, time is muscle. The
longer the duration of pain, the more damage.)

Interventions: What did you do while waiting for the ambulance?

Vital Signs
Vital signs for assessment include:

1. Pulse
2. Blood pressure
3. Respiration—number and effort
4. Lung sounds
5. Skin temperature and condition—pale, cool, sweaty?
6. Chest pain rated on a scale of 1–10
7. Description of pain
8. Cardiac/diabetic history; owing to neuropathy, diabetic patients have “silent
myocardial infarctions,” heart attacks without chest pain
SYMBOLS USED IN THIS BOOK

**The “excuse me” symbol.**
This symbol represents that inquisitive student who sits in the front row. This person is always interrupting the teacher with questions and comments. It is the same person who usually asks one last question at the very end of the class.

**The ectopic focus.**
This symbol represents ectopic, untoward, unusual beats of the heart. If there is more than one ectopic focus, each foci will look slightly different.

**Electronic or artificial pacemakers.**
These are depicted by lightning bolts to show that they are generating electrical activity.

**The cartoon characters of John McPherson.**
These are used to illustrate each rhythm and serve as a humorous and delightful portrayal of each one.

**Star.**
This represents SA and AV nodes, which are primary pacemaker sites.
“Medic 1—your signal is all broken up; we read nothing but static. What ECG rhythm do you read at your end?”

As my ambulance raced toward the hospital, I stared at the tiny screen with a green line beeping across it and felt my own heart stop. The doctor at the other end of the Medical Control was waiting. Whatever I said would determine the treatment for this patient. He would get medicated, shocked, transported, or pronounced dead, completely based on my ability to identify this rhythm correctly.

“Medic 1—this is base; What do you read!?”

*Flip and See ECG* has four fundamental concepts:

1. **Relaxed fit ECGs.**
2. **If it walks like a duck and quacks like a duck, it’s a duck.**
3. **Meaning—not memorization.**
4. **Trust yourself.**
HOW TO APPROACH ECGs

1. “Relaxed-fit” ECG
Our goal with this manual is to easily and comfortably teach you the basics of ECG interpretation so that you can start immediately. You will be reading basic ECGs in 2 hours from now.

Before we start please take a few moments to relax and get comfortable. Imagine yourself sliding into a pair of those “relaxed-fit” pants, not too tight, and loose in just the right places. This book will start you off in an easy, comfortable way.

2. If it looks like a duck and quacks like a duck, it’s a duck
While not wanting to offend purists, this book leans in the direction of simplifying concepts whenever possible and not distracting the learner with every conceivable outcome or variation.

ECG monitor interpretation is a serious medical science. This book and careful practice provide an excellent starting place for those who desire to learn ECG interpretation. Medical professionals are known to keep this book in their locker and use it as a quick review.

3. Meaning—not memorization
You can interpret almost any 3-lead ECG with an understanding of a few basic concepts. The exercises in this book are meant to be filled out as you read. I want you to write in the book, and I promise that writing the answers to the questions and tearing the pages is part of the experience.

4. Trust yourself
You can read and interpret 3-lead ECGs. Everything you need to know is here. The focus is on teaching you the most frequently encountered rhythms. Later, you can master the subtle distinctions that become important for more advanced ECG monitor interpretation.

This method has been used successfully to teach classes of nurses, paramedics, firefighters, medical students, and doctors. Based on this success, we used this system to teach our neighbors, friends, and parents. And they all were successfully reading ECGs in only a few hours.
THE HEART

Location

The scar that traditional open-heart surgery leaves is a vertical, thick red line that runs down the center of a patient’s chest, commonly known as “the zipper.”*

As a new nurse, I was assigned to obtain an apical pulse on a man who had come out of surgery. An apical pulse is taken by placing your stethoscope directly over the heart and counting the number of beats you hear in 1 minute. I stared down at the fresh, thick scar of open-heart surgery. Now all I needed to do was listen directly over the heart.

I thought his chest would be sore from having his skin peeled back. I wanted to be mindful of his pain and place the bell of my stethoscope directly over the heart, but my hand froze. Where exactly is the heart located?

I moved my stethoscope down carefully, about 1 inch below the left nipple and halfway toward the center of his chest (his sternum). I quietly listened to the lub-dub beat of his heart.

*This story illustrates where the heart is located in the chest, and it works well for that. But you should know that cardiac surgeons are currently doing minimally invasive and robotic-assisted heart surgery. Those patients do not have long thick scars; they have tiny little incisions.
The heart lies in the center of the chest, under the sternum and between the lungs. Two thirds of it lies to the left of the sternum. It is approximately the size of your fist and weighs about 11 ounces.

**Physiology (Function)**

The function of the heart is to circulate blood to all the tissues of the body. The heart is divided into a right and a left side. These two sides expand and contract simultaneously, but they receive blood flow from two separate areas of the body.

In the anatomical position (see diagram on next page) we are referring to the patient’s right and left sides. Likewise, in the heart, we are referring to the anatomical right side and left side (based on the patient’s right and left sides of the body). It is all about the patient. Remember: When you are facing the patient, your right side is the patient’s left side; however, we still refer to right and left in terms of the patient’s body, not our own.
Anatomy (Structure)

The heart is divided into two sides (right and left) and four chambers.

The two top chambers are called the *atria*. The two bottom chambers are called the *ventricles*. The heart is actually two separate pumps arranged side by side. When the atria contract, blood is pushed into the ventricles through valves. When the ventricles contract, blood is pumped out into the body and the lungs. The septum separates the heart from side to side and is both a membrane and a muscle. It is a
membrane at the top, and it changes to muscle tissue at the bottom so it can help the ventricles pump blood. One-way valves are located between the atria and the ventricles to make sure that blood that flows down but does not flow back up into the atria when the ventricles contract.

The chambers of the heart are part of the circulatory system. There are three circulatory systems at work in the heart: (1) the right side of the heart circulating blood from the body; (2) the left side of the heart circulating blood from the lungs; (3) the coronary arteries circulating oxygenated blood to the heart muscle itself.

1. Divide the heart into four quadrants.
2. Label the right and left sides.*
3. Label the atria and the ventricles.
4. Draw arrows indicating blood flow from the atria to the ventricles and out to the body and lungs.

*In medicine the anatomical position is used to designate the location of body parts. It is the patient’s right and left sides.
In coronary artery disease, the arteries that provide the heart muscle with oxygen can become narrowed or blocked. When that happens, the areas of the heart muscle (myocardium) that are supplied by that artery cannot receive oxygen. This lack of oxygen injures the heart cells, and they build up waste products. The result is a three-stage process of damage to the cells: ischemia, injury, and infarct.

**CARDIAC CYCLE**

The cardiac cycle consists of two phases: contraction and relaxation. It is like squeezing a sponge in a bowl of water. When the heart contracts (squeezes), blood is pushed out to the body. As the heart relaxes, it is expanding and refilling. These are known
as the systolic (the heart-squeezing) and the diastolic (the heart-relaxing) phases of the cardiac cycle. Both these phases must function properly for blood to circulate. A too-short relaxation phase (diastolic phase) doesn’t allow for the heart to refill, and without a proper refill, there is not enough blood for the heart to pump out during contraction (systole).

The contraction (depolarization) and relaxation (repolarization) of the heart are actually a mechanical process initiated by an electrical “spark.” When the heart is resting, the cells are negatively charged inside and positively charged outside. When an electrical impulse is introduced, there is a wave of activity, and the cells become positively charged on the inside and negatively charged on the outside. This action causes the muscle to contract.

Think of it as a “wave” at a baseball game. One person in the bleachers starts the wave by standing up and throwing his or her hands in the air. As that person sits down, the next person stands up, and the next person continues, and the next, until it goes all the way around the stadium.
Let's review: The contraction and relaxation of the heart represents a mechanical event prompted by an electrical impulse. There are two phases for each heartbeat: depolarization and repolarization. In the first phase the heart (myocardial) cells receive an electrical impulse and the heart depolarizes, changing from a negative charge inside the cells to a positive charge. The impulse spreads through the muscle, causing the muscle to contract like the wave at the baseball game.

The heart cells then rest and repolarize, returning to a negative charge on the inside and a positive charge on the outside, and are now ready for the next stimulus.

Repolarization has two phases: relative refractory, when the heart is susceptible to strong stimulation, and absolute refractory, when the heart cannot receive any stimulation, no matter how strong the impulse.

All this electrical activity can be recorded on paper. That recording is known as an electrocardiogram, or ECG (also sometimes abbreviated as EKG).

The ECG records the electrical activity of the heart. We are watching the electrical impulses move through the heart. Most times, fortunately, this also represents mechanical functioning as well. Blood is moving, vital organs and tissues are getting the oxygen they need (perfusion), and everybody’s happy.

**CONDUCTION PATHWAYS**

Conduction pathways are the expected paths, which electrical activity will take as it travels through the heart. Unlike other cells in the body, heart (myocardial) cells can create and conduct electrical impulses. This specialized ability is called automaticity.
We expect that electrical impulses will be created by the primary pacemaker sites and conducted by the usual pathways.

**Ode to a Node**

*Have a heart, and have no fear,*

*The SA node is over here!*  
*Beating at a constant rate:*

*60–100 is just great.*  
*The AV node can make a show*  
*If SA node has gone too slow.*  
*40–60 isn’t bad --*  
*If it’s all you’ve got, you will be glad.*  
*Should the whole thing drop its speed,*  
*“His” and bundle branches will take the lead.*  
*And that, my friend, is the whole and part*  
*Of the conduction system of your heart.*

The electrical stimuli for the heart can be created by any myocardial cell, but usually it is created by primary pacemaker sites that are located throughout the heart. The primary pacemaker sites are as follows:

- Heart Sinoatrial (SA) node (responsible for atrial contraction)
- Atrioventricular (AV) node (the gatekeeper)
- Bundle of His (named for its discoverer and pronounced Hiss)*
- Right and left bundle branches*
- Purkinje fibers*

**Sinoatrial Node**

The sinoatrial (SA) node is located in the upper right wall of the right atrium. The SA node is the primary pacemaker for the healthy heart for two reasons:

1. It is located *highest* in the heart, on the upper right wall of the atrium.
2. It has the *fastest* intrinsic firing rate: 60–100 beats per minute. As long as other pacemaker sites are receiving stimulation from the SA node, they will not create additional impulses.

*Responsible for ventricular contraction.*
The intrinsic rate of the SA node is ______________ beats per minute
Answer: 60–100

Excuse Me
What do you mean by “intrinsic rate”?

Answer:
Intrinsic means inborn, built in, or preset. The SA node is preset at the highest speed, 60–100 beats per minute. Other nodes of the heart, such as the AV node, monitor the heartbeat. If it drops below 50 beats per minute, the AV node will take over pacing the heart.
The SA node fires impulses that contract the atria.

1. Place a star at the SA node.
2. Shade the atria.

3. The function of the SA node is to contract the ________.
4. Fill in the intrinsic firing rate: ___________ beats per minute.

**Answers:** atria; 60–100

**Atrioventricular Node**

The atrioventricular (AV) node is located on the floor of the right atrium just above the ventricles.

Place a star on the AV node.
The AV node has one main function: to properly regulate impulses from the SA node.

To do this, the AV node performs in the following ways:

1. Under normal circumstances, the AV node slows down the electrical current before the signal is permitted to pass through to the ventricles. This delay ensures that the atria have a chance to fully contract before the ventricles are stimulated.

2. If electrical impulses from the SA node are being generated too fast, the AV node selectively allows only some impulses to be conducted. In that case, the AV node is acting as a gatekeeper.

3. If electrical impulses from the SA node are being generated too slowly, the AV node can generate impulses at its own intrinsic rate (40-60 beats per minute).

If we take the pulse of a patient, and it is 48 beats and regular, we might look to see if the AV node has become the primary pacemaker.

Extra Credit

If the SA node was not firing and the AV node took over, what would be the heart rate (pulse) of the patient?

It is a range of ______________ beats per minute

Answer: 40–60

The AV node further conducts electrical impulses to the bundle of His (pronounced Hiss). The bundle of His carries the impulses from the AV node to the right and left bundle branches and eventually to the Purkinje fibers. These three systems together—the bundle of His, the left and right bundle branches, and the Purkinje fibers—are responsible for contracting the ventricles.

1. Divide the heart into the four chambers.
2. Star and label the SA node.
3. Star and label the AV node.
4. Draw and label the bundle of His.
To contract fully, the ventricles require the assistance of the right and left bundle branches and the Purkinje fibers.

The excitation or passage of an electrical impulse along these pathways causes the ventricles to contract.

1. Outline the bundle of His, the right and left bundle branches, and the Purkinje fibers.
2. Shade the ventricles to show them contracting.
3. Fill in the intrinsic firing rate of the AV node: _____________ beats per minute.
4. The function of the bundle of His, the left and right bundle branches, and the Purkinje fibers is to contract the ______________.

**Answers:** 40–60; ventricles
The cells of the ventricles have the slowest intrinsic firing rate in the heart. They fire at 20–40 beats per minute.

The final phase of each heartbeat is the relaxation phase. In this relaxation or refractory phase, the heart relaxes and repolarizes.

During the absolute refractory phase, the ventricles cannot receive further stimulation.
Let’s review:

*The SA node* is located in the upper right atrium. It has an intrinsic firing rate of 60–100 beats per minute and is the primary pacemaker for the heart.

*The AV node* is located on the floor of the right atrium. It has an intrinsic firing rate of 40–60 beats per minute and is known as the gatekeeper of the heart because it regulates impulses coming from the SA node.

*The bundle of His, the left and right bundle branches, and the Purkinje fibers* are located in the septum and the lining of the ventricles. They have an intrinsic firing rate of 20–40 beats per minute. These three work together to contract the ventricles.
THE ECG

The electrocardiogram (ECG) monitor records electrical conduction through the heart. Electrical conduction is recorded through electrode pads placed on the patient’s chest. These electrode pads can detect the electrical activity generated by the myocardial cells. Cables attach the electrodes to an ECG monitor. There is one positive electrode, one negative electrode, and one ground electrode.

Lead Placement and Vectors

The electrodes are placed on the patient with one electrode on each side of the patient’s chest under the clavicles, and one on the lower left side of the body.
You can set the monitor to view the heart in lead I, lead II, or lead III.

The setting of the machine will determine which electrode is positive, which electrode is negative, and which is the ground. The positive electrode is called the “eye” because the ECG machine is looking through the positive electrode at the electrical impulses as they travel through the heart.
The same complex seen in three different leads.
There are two types of electrical impulses that affect the waveform of the ECG.

1. Location of the negative and positive electrode, because energy flows from the negative electrode toward the positive electrode.
2. Negative to positive, depolarization of the cells of the heart, which moves from the upper right to the lower left as it descends down the heart (shown on p. 21).

When you choose to look at the heart in lead I, lead II, or lead III, you are changing the angle of your picture, and therefore a “normal” complex on the ECG would appear different in each of the different leads. If the heart were an exit sign, here is a picture of how it would look in lead I, lead II, and lead III. All of these views would represent a normal exit sign picture taken from different angles.

Electrical activity moving toward the “eye” electrode will be viewed as upright complexes on the monitor. The image on the ECG monitor is like the view function of a camera. The electrical activity in the heart remains the same, but the picture changes depending on where in the heart you are taking the picture.
This is the same complex viewed in three different leads.

There are two considerations when choosing a lead for monitoring:
1. Is there a specific part of the heart I want to watch?
2. Can I get upright complexes with a smooth, stable baseline?

There is an episode of an old show called *The Honeymooners* in which Ralph is holding a TV antenna and wandering from room to room saying, “How’s the picture now, Alice?” In this case we are asking you, “How’s the picture now?”

The proper lead is selected by finding the best picture, or monitoring a specific part of the heart.
In the case of ECG tracings, the path of electrical conduction will determine the best picture. The settings for lead I, lead II, and lead III are settings on the monitor. It can be a knob that makes a selection or a touch-screen button. If the heart has an altered conduction pattern because of disease or injury, or if you suspect damage to a specific area of the heart (especially the back of the heart), you would select a lead that shows you the best picture of your area of concern.

Reading ECGs: P waves, QRS Complexes, and T Waves

Atrial and ventricular depolarization and repolarization are electrical events that are seen as waves on an ECG monitor or on ECG paper. As the electrical impulse is conducted downward through the heart, we can watch its path on the ECG monitor. Each wave on the ECG represents the path of an electrical impulse as it is conducted through the heart.

**P Wave**
The P wave represents the depolarization (contraction) of the atria.
1. Place a star on the SA node.
2. Shade the atria.

3. The function of the SA node is to contract the ________.

Answer: atria

Draw and label a P wave.

A P wave.

P-R Interval
A normal P-R interval indicates that an impulse conducted normally from the sino-atrial (SA) node to the atrioventricular (AV) node. The impulse made contact with the atria on the way down and followed a regular, unobstructed course.

The P-R interval is the time it takes for an electrical impulse to originate in the SA node and be conducted through the atria and the AV node. The P-R interval is measured from the beginning of the P wave to the beginning of the QRS complex. The P-R interval includes the entire P wave and the tail of the P wave as it approaches the QRS interval. It represents depolarization of the SA node and the atria down to the AV node.

Draw and label a P wave with a P-R interval.

A P wave with a P-R interval.
QRS Complex
The QRS complex represents the depolarization (contraction) of the ventricles.

1. Place a star on the bundle of His; draw the right and left bundle branches and the Purkinje fibers.
2. Shade the ventricles.

3. The function of the bundle of His, the right and left bundle branches, and the Purkinje fibers is to contract the__________.

**Answer:** ventricles

The QRS complex consists of the following:

- The Q wave, which is the first negative or downward deflection of the complex. The Q wave often is not seen. If you can see a Q wave, it may be a marker of previous cardiac damage (more on that later).
The ECG

**The R wave**, which is the first upward deflection.

![Diagram of an R wave](image)

**The S wave**, which is the rest of the complex, is the next downward and upward deflection.

![Diagram of an S wave](image)

Putting it together:

![Diagram of a combined QRS complex](image)

**ST-Segment**

The ST segment is the area between the end of the S wave and the beginning of the T wave. The ST-segment should rest on the isoelectric line.

**T Wave**

The T wave represents the heart repolarizing (relaxing). This is called the *refractory period*.
The T wave is rounded. It is usually larger and more equally rounded than a P wave. Think of the shape of a turtle shell.

A P wave, a P-R interval, a QRS complex, and a T wave

What would you see if the SA node didn’t fire? Draw and label answer:

Answer: No P wave; QRS or QRS T only

What would you see if the SA node fired but the impulse was blocked at the AV node? Draw and label answer.

Answer: P wave only

What would you see if there was a delay at the AV node? Draw and label answer.

Answer: Long P-R interval
INTRODUCTION TO THE RHYTHMS

Naming Rhythms
To have success in naming rhythms, you’ll need the following vocabulary:
atrial—originating in the atria
brady—slow
-cardia—pertaining to the heart
compensatory—pause when the heart holds a beat
contraction—an electrical impulse was conducted and contracted the heart muscle
irregular—the R-R interval is irregular
premature—the complex came earlier than expected
regular—the R-R interval is equal
sinus—normal configuration of P wave, QRS complex, and T wave
tachy—fast
ventricular—originating in the ventricles

Electrocardiograms (ECGs) are named for the pattern they represent.
Naming rhythms is like being a detective in a mystery game. All the clues are right there on the strips.

Step 1: Relax and get comfortable.
Step 2: Flip to the front of this book, and pick up Cohn’s Pocket Guide to Adult ECG Interpretation.
Step 3: Read and answer the questions as they are listed on the pocket guide, and you’ll be interpreting ECGs in the next 10 minutes.

Clues to Identifying Rhythms
The best approach to identifying rhythms is to use a systematic method. One such system is presented in Cohn’s Pocket Guide to Adult ECG Interpretation on the inside front cover. You should use this guide each time you identify a rhythm. Listed here are additional pointers for ECG recognition.

1. Look for complete complexes. The QRS complex is the tallest complex. Find the QRS complex; before it is the P wave and after it the T wave. This doesn’t always work, but it is always a good start.
2. Presence of P waves. Rhythms are usually named for their site of origin. Almost all rhythms with upright P waves originate in the atria.
3. Rate is the other clue to the origin of a rhythm. For example, a rate of 40–50 may be junctional because 40–50 beats per minute is the intrinsic firing rate of the atrioventricular (AV) junction. A rhythm strip with a rate of 44 and no P waves is considered to be junctional in origin.
4. Review the strip for *wildly abnormal beats*; calculate rate and name on the basis of the underlying rhythm, not the abnormal beats.

**Normal Sinus Rhythm**

In normal sinus rhythm, the impulse follows a normal path of conduction: from the sinoatrial (SA) node to the AV node, to the bundle of His to the Purkinje fibers. The tracing is of a normal rate (60–100) and rhythm (regular).
In normal sinus rhythm, impulses follow the normal path of conduction.
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**Sinus Arrhythmia**

In sinus arrhythmia a normal sinus rhythm is found to have an irregular R-R interval. All the complexes are present, in the correct order and in a correct relationship to each other, but the R-R is varied or irregular. This rhythm is seen in some people as a result of normal breathing—nothing to get excited about.
In sinus arrhythmia only the R-R interval varies.
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**Sinus Bradycardia**

In sinus bradycardia all the complexes are present and upright. Each complex is complete and each interval is normal, but the rate is below 60 beats per minute. In a young and healthy individual, it is the sign of a well-trained athlete. In an older person who is not in top physical condition, it can be the first indicator of a more serious cardiac situation.
In sinus bradycardia complexes and intervals are normal, but the rate is slower.

At La-Z-Boy recliners national headquarters.

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Sinus Tachycardia

In sinus tachycardia all the complexes are present and upright. Each complex is complete and each interval is normal, but the rate is above 100 beats per minute. Sinus tachycardia can be the result of fright, fever, or pain. Sinus tachycardia can also signal a cardiac event.
In sinus tachycardia complexes and intervals are normal, but the rate is faster.
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Atrial Flutter

In atrial flutter a single strong ectopic focus in the atrium starts to beat fast, 240–360 beats per minute. The AV node acts as a gatekeeper in this rhythm, allowing only some impulses through to the ventricles.
In atrial flutter a single strong ectopic focus is sending out rapid impulses.
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Atrial Fibrillation

In atrial fibrillation many weak ectopic foci in the atria beat in an uncoordinated pattern, resulting in an uneven baseline of many tiny P waves, known as fibrillatory (f) waves in the atria. Eventually, the ventricles receive enough electrical stimulation from the atria to contract, or they contract on their own. This rhythm is characterized by a coarse baseline and an irregular distance between the QRS complexes.

Apparently there was some confusion as to exactly when during the game the Fegley High Marching Band was supposed to perform.

In atrial fibrillation many weak ectopic foci in the atria all fire at different times, causing an uncoordinated effort and confusion.

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Supraventricular Tachycardia

Supraventricular tachycardia occurs when there is a fast, strong stimulus from an ectopic focus that is above (supra) the ventricles (ventricular). The ectopic focus is below the primary pacemaker site of the SA node but above the AV node, and the heart conducts every beat. In supraventricular tachycardia the heart rate is 150–250 beats per minute.

This can result in an inadequate refilling time, similar to squeezing a sponge quickly under water and never allowing it to expand completely. This rapid action can result in low blood pressure. Additionally, a person’s heart cannot sustain this rhythm for long because the muscle itself gets tired.
In supraventricular tachycardia the impulses are conducted very quickly, but it is almost impossible to sustain this rhythm.

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**Ventricular Tachycardia**

Ventricular tachycardia is the result of one strong ventricular ectopic focus. The heart cannot sustain this rhythm for very long. Ventricular tachycardia can be “stable,” meaning with a pulse, or “unstable,” meaning the patient is hemodynamically compromised, or pulseless.
Ventricular tachycardia has one strong ventricular focus.
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**Torsades de Pointes**

Torsades de pointes is a rhythm in between ventricular tachycardia and ventricular fibrillation. *Torsades de pointes* is French for “twisting of the points,” which

Unable to find guys who could dance in the school musical, choreographer Nelda Crantz develops and tests her automatic dancing machine.
describes the way that the QRS complex twists around itself. You can see this if you examine a strip of torsades de pointes carefully. Look at the wide part of the QRS, follow it in the strip, and suddenly what should be the wide part of a complex becomes the narrow part. Torsades de pointes can be caused by heart blocks and slow rhythms, hypokalemia, hypomagnesemia, drug overdoses, and anything that causes a long QT syndrome.

Torsades de pointes originates in the ventricles, but it is not known whether it is from a single ectopic site or many sites. Unlike ventricular tachycardia, the wave forms increase and decrease in a repeating pattern about the baseline. Torsades usually starts with a prolonged QT interval.

The QRS complexes are wide, bizarre, and greater than 0.12 second. The rate is often greater than 150 beats per minute.
In torsades de pointes the complex twists and turns on itself.
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**Ventricular Fibrillation**

Ventricular fibrillation is the beating of many weak ectopic foci in the ventricles, resulting in an uncoordinated undulation instead of a coordinated contraction. It is a rhythm that cannot circulate blood and is not compatible with life. If you could see the ventricles, they would resemble a squirming bag of worms.
Ventricular fibrillation is the result of the uncoordinated beating of many weak ectopic ventricular foci.

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**Asystole**

Asystole, or a flat line, is not a rhythm but the absence of all electrical activity. Unless swift and sure intervention takes place, this will lead to death. Often it leads to death anyway, even if prompt medical attention is delivered.
Heart Blocks
Heart blocks most commonly affect the AV junction. The impulse is either slowed at the AV junction or stopped at the AV junction.

There are four types of AV blocks.

First-Degree AV Heart Block
In first-degree AV heart block, the impulse is delayed at the AV junction.
In first-degree AV heart block, there is a delay at the AV node.  
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Second-Degree AV Heart Block, Also Known as Mobitz Type I (Wenckebach)
Second-degree AV heart block, Mobitz type I, is characterized by a progressively increasing, abnormally long delay at the AV node that causes a longer and longer P-R interval, until no complex is conducted. This results in “group beating,” which looks like groups of beats alternating with areas of blank space. This is seen best with the strip held across the room or at least at arm’s length.
Second-Degree AV Heart Block, Also Known as Mobitz Type II

Second-degree AV heart block, Mobitz type II, is an intermittent block at the AV node that conducts some impulses normally but completely blocks others in a pattern. For example, two beats conducted, one blocked (known as a 2:1 ratio) or three beats conducted, two blocked (known as 3:2 ratio). In the following illustration every other impulse is conducted (1:1 ratio).
In second-degree heart block, Mobitz type II, impulses are conducted in a ratio.

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Complete Heart Block (Third Degree)
In third-degree, or complete, heart block, there is no communication between the atria and the ventricles. P waves and QRS complexes are generated independently from one another with the atria generating P waves and the ventricles generating QRS complexes.
In third-degree heart block, there is no communication between the atria and the ventricles.
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**Artificial Pacemakers**

Pacemakers are battery-operated electrical devices that can fire either “on demand,” meaning whenever the heart rate drops below a certain speed, or at a preset rate. They are composed of leads that are placed in the heart either in the atria or the ventricles, or both, and a container that holds the batteries and is known as a “can.” A pacemaker usually is placed surgically under the clavicle.
Paced rhythms have a narrow “pacing spike” followed by either a P wave (if the pacemaker is in the atria) or a QRS complex (if the pacemaker is ventricular). Pacemakers can even be “AV” atrial and ventricular. Then you would see a little pacemaker spike followed by a P wave and a larger pacemaker spike followed by a QRS complex.
Electrical pacemakers are placed in the heart to keep the rate and rhythm regular and prevent it from dropping below a set speed.

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The electrocardiogram (ECG) complexes measure the electrical events; the paper measures the time. The ECG paper rolls out of the machine at a preset speed of 25mm, or 1 inch, per second. The paper is marked off in a grid, with each line 1mm apart. Every fifth line is darker and thicker so that very small boxes can be counted accurately.

Each small box represents 0.04 second. Each large box is made of five small boxes and represents 0.20 second.

An electrical event that takes 0.08 of a second would create a line two small boxes long.
What is normal?
The criteria for a normal ECG are reproduced on the back of *Cohn’s Pocket Guide to Adult ECG Interpretation* and are as follows:
One small box—0.04 second
One large box—0.20 second
P wave—3 small boxes or 0.12 second wide
P-R interval—(count from the beginning of the P wave to the beginning of the R wave) 3–5 small boxes or 0.12–0.20 of a second wide
QRS complex—1–2½ small boxes or 0.04–0.10 second wide; the height of the
QRS is adjustable on each machine
T wave—upright, well rounded, and less than half the height of the QRS
complex
The ECG is a graphic representation of the electrical activity in the heart. By
counting the boxes, we can establish the time the complex took to travel. By
counting the number of complexes in 1 minute, we can establish a rate.

Here’s how it works.

Pretend your archenemy, Kneehigh Snodgrass, is tracking you and your car on
radar to follow your whereabouts. Kneehigh Snodgrass must pay for each minute
he is tracking you on radar. On the first day, you drive quickly to work. You create
a short, narrow path as he watches you on the radar. The next day you are stuck
in traffic. It takes you longer to travel, and you take a detour off the road and back
on to go around an accident. That detour would be reflected as a longer route. The
longer route would take more time; cost more money in radar charges; and create
a wide, bizarre tracing on the radar. And so it is with an electrical impulse that takes
a longer or unexpected route: It takes longer, and the complex is recorded as a wide
and bizarre tracing.

In ECGs, if the complex is wider than normal, it means that the electrical impulse
was slowed somewhere in the heart. If the complex is narrower than normal, it
means that the impulses are passing more quickly through the heart. If the ECG
complex takes on a strange shape, it means the impulse was rerouted through the
heart.

CALCULATING RATE

It is unwieldy and cumbersome to count 60 seconds of ECG strip. There are a num-
ber of methods that have been established to count rate. Rulers are also available to
assist in this calculation.

The easiest, most accurate method is called the 6-second strip method. Instead
of counting the number of complexes in 60 seconds, we count the number of com-
plexes in 6 seconds and multiply by 10 (or just add a zero).

Depending on design of the ECG strip you are using, 6 seconds of strip is equal
to the following:
- Thirty large boxes (6 seconds) or
- Six 1-second markers (6 seconds) or
- Two 3-second markers (6 seconds) or
- One 6-second marker (6 seconds)
Timing is an essential part of being a yearbook photographer.

In ECG interpretation, timing is everything.

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Practice calculating rate.

Rate is __________ beats per minute.

Answer: 80

Rate is __________ beats per minute.

Answer: 40

Rate is __________ beats per minute.

Answer: 70

Hint: Do not count the premature ventricular contraction.

By far the quickest way to calculate rate is to use the rate calculator now included with this book. To use the rate calculator, place the black arrow on top of any complex. Count THREE (3) complexes away from the arrow. The number that the THIRD complex falls on is the rate of the heartbeat. Here is a strip for practice:
The rate is 50 beats per minute, by both systems.
Here is a handy trick for counting fast rhythms. It works only for rhythms that are regular and over 50 beats per minute.* You will be able to see if a rhythm is regular by checking the R to R intervals. This rate calculation method involves looking at one R to R interval and determining the rate on that basis.
The way this system works is as follows: You find a QRS complex where the R wave falls right on a heavy line.

At this complex you say **dot**.
In skydiving† you say the word *dot* when your body is in the proper position outside of the plane and you are ready to let go and start your skydive. You say this because there is a red dot painted on the outside, underside of the wing. If you can see the red dot, then your head is up and your back is arched. So you see the red dot, say *dot*, your body is in proper position, and you let go. We will say *dot* when we find an **R wave** on a heavy line. That will tell us we are in the right position.

*If a rhythm is irregular or less than 50 beats per minute, you should count for at least 10 seconds by ECG strip or 30 seconds by pulse check. If the rhythm is very slow or very irregular, it is most accurate to count for a full minute.
†Skydiving and determining unusual axis on twelve leads are my two favorite extreme sports.
How to Interpret ECGs

At the next heavy red line, say 300
At the next heavy red line, say 150
At the next heavy red line, say 100
At the next heavy red line, say 75
At the next heavy red line, say 60
At the next heavy red line, say 50
At the next heavy red line, say, “Could I please have a ten-second strip?” (The reason you say that is that the system only works for normal or fast rates; for bradycardic rates under 50 you need a 6-second strip to count)

The QRS complex after the one where you said dot is the one that tells you the rate. You stop counting when you get to the next QRS complex. Again, when you get to the next QRS complex after the dot, you stop counting, and that is the one that signals the rate.

Here is a practice strip:

In this strip we say, 300, 150, 100. The next QRS complex is between the 150 and 100. Actually, if you look carefully, you will see that the complex is 1½ small boxes before the heavy red line at the 100 mark. You would estimate this rhythm at about 115 beats per minute. This strip is 28 boxes long, not 30, so you cannot directly do a 6-second strip count. When you use this method, the count is an estimate, and it is based on one beat of the heart.

Here is a complex on a heavy line. At this complex, say ____________.

**Answer:** **dot**
Here is one more:

What is the rate?

**Answer:** 150 beats per minute. Say 300 at the first solid line, say 150 at the next solid line—the complex falls on the solid line, so you stop counting there.

This method also can be used to calculate the atrial rate in rhythms such as atrial flutter.

**Measuring ECG Waveforms**

To help us measure waveforms, each segment has a specific beginning and end. We use the standard measures to decide if the complex is longer or shorter than normal.
When you are evaluating the P wave, look for location, configuration, and distance from the QRS complex.

When you are evaluating the P-R interval, you should know that it contains both the P wave and the P-R interval and represents depolarization from the sinoatrial (SA) node through the atria to the junction right above the ventricles.
When you are evaluating the QRS complex, you measure from the first downward deflection of the Q wave and continue to the end of the S wave. A Q wave is often not seen, in which case you would measure from the beginning of the R wave. A significant (pathologic) Q wave (one third the height of the QRS and at least one small box in duration) can be seen in patients who have had a prior myocardial infarction.

The ST segment signals the end of the ventricular contraction.

The T wave represents the ventricular repolarization and refilling. The heart cannot be stimulated in the early part of the T wave, known as absolute refractory. It is dangerous for the heart to receive stimulation during the T wave.
The QT interval represents the ventricles in both depolarization and repolarization. It is measured from the beginning of the Q wave to the end of the T wave. If a Q wave is not present in the QRS complex, then the measurement it begins with is the R wave.

U waves are often not seen on a rhythm strip. They are usually seen when the rate is slow. If present, they are the first slope after the T wave and occur after the T wave and before the P wave.
A Helpful Hint
Every patient’s P waves, QRS complexes, and T waves look slightly different. If you are ever stuck and cannot distinguish between the P waves and the T waves, try this:
♥ Find the QRS complex, and look before it; that complex should be a P wave
♥ Find the QRS, and look after it that; that complex should be a T wave.
♥ Find another QRS complex, and try it again to check your first finding.
This method works for most basic rhythms.
To determine if a rhythm is regular, check the R-R interval. The R-R interval is measured from the peak of one R wave to the peak of the next (top of the QRS complex to top of the next QRS complex).

ECG Calipers

An ECG caliper is a tool with two functions. Calipers can help to determine if complexes in an ECG rhythm are regular (reminder: “regular” is different from “normal”) and calipers can be used to measure the width of complexes or intervals.
Calipers have no specific measurement unit. In this illustration, they are shown measuring a distance of five large boxes or 25 small boxes.
Calipers can also be used to measure the width of an interval or complex. In illustration A calipers are being used to measure an R to R interval. In A and C the R to R interval is regular. In B the caliper has found the R to R interval is regular. Fancy calipers are not necessary, but calipers make it easier to find hidden complexes and measure intervals, large and small. If no calipers are available, you can just use marks on the side of a piece of paper with much the same effect.

Lines on paper can be used to measure the ECG rhythm for regularity. Here a paper measure is shown to determine if the P waves are regular.
The Isoelectric Line

There is an imaginary line running across the center (give or take) of the ECG paper, halfway between the top and bottom. This imaginary line is called the isolectric line. The isolectric line is defined as the place on the ECG paper where the complexes return to the baseline. If you took a ruler and held it under the ECG tracing and you drew a line with a pen, you would create a visible isolectric line. But we don’t usually do that; we just draw it with our mind.

The purpose of the isolectric line is so we know whether complexes are above it or below it, and so we have a starting place to measure the height of complexes.

Ectopic Activity

Ectopic activity is defined as a cell that creates its own impulse outside of the usual pacemaker sites. All the cells in the heart can create electrical activity on their own. Usually, there is no need for this and cells conduct impulses from the primary pacemaker sites. Occasionally, a little oxygen-deprived, irritable, frustrated cell goes off and fires on its own. This is known as ectopic or aberrant activity. Ectopic means outside of the usual pacemaker sites. When this happens, the ectopic beat is recorded on the ECG as a different-looking complex. An oxygen-deprived, irritable cell is known as an irritable focus, or the plural, irritable foci.

If the ectopic beat is originating in an irritable focus close to the SA node, the beat looks almost like a normal P wave and conducts a normal-looking QRS complex. There are two clues to recognizing an ectopic beat:
1. It looks slightly different.
2. It comes at an unexpected time
A complete complex

A regular path of conduction.

Outline the path of conduction.

Draw an ectopic focus in the atria.

An ectopic focus in the atria
Premature Atrial Contraction
This is called a premature atrial contraction:
Premature means early, or before the SA node was expected to fire.
Atrial means from the atria.
Contraction means beating or contracting of the heart.
It is from the atria because the impulse originated in the atria and it created a complex that looked like a P wave but not exactly like the other P waves, and it conducted a normal-looking QRS complex.

Two interesting facts:
1. The closer the irritable focus is to the SA node, the more the premature atrial contraction will resemble a P wave.
2. The closer the irritable focus is to the atrioventricular (AV) node, the shorter the P-R interval can be.

Close to the SA node, the premature atrial contraction looks like a P wave (Illustration A above).

Close to the AV node, the premature atrial contraction shortens the P-R interval (Illustration B above).
Premature Junctional Contraction*
When the AV node fires on its own, there may be no P wave or there may be an inverted P wave (backwards or retrograde conduction).

1. Draw the AV node firing.
2. Shade the ventricles.
3. Shade upward toward the bottom of the atrium.

1. The AV node firing independently.
2. The shaded area contracts.

*Also known as premature nodal contraction.
If the AV node becomes irritable or fussy (usually as a result of a lack of oxygen), it sends out a spark on its own, resulting in the following:

- no P wave
- inverted P wave from retrograde conduction
- or
- A normal complex followed by a premature contraction.

1. An inverted P wave or no P wave
2. A stand-alone QRS complex and T wave

This is called nodal or junctional because it originates in the AV node, also known as the AV junction.

If the impulse is conducted backward up through the atrium, it may appear as an inverted P wave on the ECG.

**Premature Ventricular Contraction**
When an irritable or ectopic focus in the ventricle fires independently, it is called a premature ventricular contraction. These premature ventricular contractions travel sideways across the ventricles. This conducts as a wide and bizarre complex on the three-lead ECG.

1. Draw an irritable focus in the ventricles.
2. Shade the ventricles to show them contracting.

An irritable focus in the ventricles.
There can be more than one ectopic focus in the ventricles. If there is more than one, each conducted premature ventricular contraction will look different from the rest.

**SUMMARY**

Contraction and relaxation of the heart are mechanical events launched by electrical activity. The ECG is usually a good reflection of the current status of the heart—but not always.

You must confirm that what you see on the monitor is what is happening inside the patient. You should feel a pulse each time you see a complex on the
monitor and should perform frequent blood pressure checks. In all cases, \textit{you should always treat the patient and not the monitor.}

In summary, the ECG records the \textit{electrical activity} of the following:
1. The atria as they depolarize (the P wave)
2. The ventricles as they depolarize (the QRS complex)
3. The relaxation phase of the ventricles (the T wave), when the entire heart rests, relaxes, and repolarizes

In most cases the electrical activity of the heart accurately reflects the mechanical action inside.

The ECG records any and all electrical impulses in the heart. It records complexes that originate from primary pacemaker sites: the SA node, the AV node, the bundle of His, the left and right bundle branches, and the Purkinje fibers. It also records untoward, unwelcome impulses from elsewhere. The primary pacemaker sites usually lead to a regular rhythm, in which the R-R interval (the measurement from R wave peak to R wave peak) remains constant.

Because all the cells of the heart can create their own electrical impulses (a phenomenon known as \textit{automaticity}), we occasionally see \textit{ectopic} pacemaker sites. \textit{Ectopic} means outside or away from the usual pacemaker sites, just as an ectopic pregnancy is one that is outside the uterus.

Complexes that look the same come from the same place in the heart. That place can be either a primary pacemaker, such as the SA node, or an ectopic pacemaker, such as one small, irritable, oxygen-deprived cell in the atria.

If the heart is ready to receive an electrical stimulation, it conducts any impulse that comes along and the ECG monitor or paper records it.

\begin{itemize}
    \item \textbf{Excuse Me} \hspace{1cm} \textbf{Answer:}
    \item \textit{What causes the heart to change rhythms?}
    \item \textit{Ectopic foci, damage to the heart muscle or the conduction pathway, or underlying medical conditions such as fever, hypoxia, and hypovolemia.}
\end{itemize}

There are two basic kinds of rhythm disturbances:
1. \textit{Rate} disturbances, including:
   \begin{itemize}
       \item too fast
       \item too slow
   \end{itemize}
2. \textit{Conduction} problems, including:
   \begin{itemize}
       \item delays in conduction
       \item alternative pathways of conduction
       \item conduction of ectopic impulses
       \item metabolic imbalances
   \end{itemize}
**HOW TO USE THE FLIP AND SEE PORTION OF THIS BOOK**

Please turn to the Rhythm section of this book for the next exercise. To use the Flip and See Rhythm section, you should do the following:

1. Separate the pages at the perforated line.
2. Flip just the right side of the book to create variations of rhythms.
3. Compare the rhythms side by side to see how the abnormal tracing looks next to the normal one.

To use as a reference text, you can view rhythms in full strips across the page.

In reading 3- and 12-lead electrocardiograms (ECGs), the practitioners ask themselves: How does this compare to the normal rhythm that I expect to see?

**FLIP AND SEE GUIDED TUTORIAL**

Here is a brief explanation of the defining characteristics of each rhythm. Try to view each rhythm as a pattern.

1. With both sides of normal sinus rhythm placed side by side, take a look at the pattern. All the intervals are regular and normal, with no bizarre ectopic activity. The rate is 80 beats per minute; the R-R intervals are regular. Count a 6-second strip.
2. *Flip just the right side of the page.* This is also a regular rhythm. If you check the R-R intervals, some are slightly uneven. This rhythm, sinus arrhythmia, results from one of two causes: Either it represents the patient’s normal breathing, in which case it is completely benign, or it can be nonrespiratory, mostly found in diabetic and older patients. The rate here is 70 beats per minute.
3. *Flip just the right side of the page.* All complexes are present, P-QRS-T, but this rhythm is slow: 40 beats per minute. The prefix brady- means slow. This rhythm is sinus bradycardia. It can be a normal finding in a well-trained athlete, but in an 87-year-old with an extensive cardiac history, it could be a sign of damage.
4. *Flip just the right side of the page.* This one looks normal but fast: 140 beats per minute. Anything over 100 is considered sinus tachycardia. Tachy- means fast. This can be a response to certain conditions such as fever, fright, or hypoxia. When the rate starts to go very fast, P waves can be buried in the preceding complex.
5. *Flip just the right side of the page.* Counting in from the right, look at the first and sixth P waves. They are unusually shaped and come earlier than expected. They must be atrial in origin, because the QRS complexes and T waves that follow are conducted normally. They are early atrial beats known as premature atrial contractions.
6. The first complex on the right-hand side of the page is certainly wide and definitely bizarre looking. This is called a *premature ventricular contraction*. If all of the wide, bizarre complexes look the same, they are called *unifocal premature ventricular contractions* because they come from the same place in the ventricles. If they look wide, bizarre, and *different*, they are called *multifocal premature ventricular contractions*.
Multifocal foci create PVCs that look different from each other.

7. *Flip to page 111*. Are there any P waves present, or are those all P waves? Actually, they are all *flutter* waves, also known as *F waves*. In *atrial flutter* an ectopic focus in the atrium is beating fast, up to 350 beats a minute. In this case the atria are beating at 210 times a minute. The AV node is acting as a gatekeeper and allowing only every third impulse to contract the ventricles.
8. *Flip just the right side of page 113.* This rhythm shows many weak ectopic foci in the atria. This produces an uncoordinated beating of the atria and “bag of worms” effect. In *atrial fibrillation* the baseline may appear to have a few actual P waves but is made up mostly of *f waves*. The lower-case *f* stands for *fibrillatory*. The R-R interval is irregular in this rhythm, because eventually all these small atrial contractions generate an impulse large enough to conduct to the ventricles.

![Diagram of SA node and atrial fibrillation]

**Excuse Me**
How can you tell the difference between atrial fibrillation and normal sinus rhythm in a bouncy ambulance, where the baseline is wavy?

**Answer:**
Check the R-R interval. Normal sinus rhythm has regular R-R intervals, whereas atrial fibrillation has irregular R-R intervals. In normal sinus rhythm with a bouncy baseline or a loose lead, the R-R interval remains constant, whereas in atrial fibrillation, the many weak foci in the atria make the R-R interval irregular in appearance and measurement. Place p. 137 (normal sinus rhythm with loose leads) and p. 113 (atrial fibrillation) together, and see the difference.

9. *Return the booklet to normal sinus rhythm on the left. Turn just the right side of the page to resume the lesson, on p.115.* *Supraventricular tachycardia* or *paroxysmal supraventricular tachycardia* is a fast heart rate, 140–250 beats per minute. Supraventricular tachycardia originates above (supra-) the ventricles but below the sinoatrial (SA) node. It is characterized by a rapid heart rate, one that is so fast that sometimes the P wave is buried in the preceding complex.
Excuse Me
How can I distinguish a fast sinus tachycardia from a supraventricular tachycardia or paroxysmal supraventricular tachycardia?

Answer:
(1) Look at the P wave. Sinus tachycardia’s pacemaker is the SA node. The pacemaker for paroxysmal supraventricular tachycardia and supraventricular tachycardia is anything above the ventricles, excluding the SA node. (This will be a hard determination to make if the P waves are buried in the preceding complex.) (2) Check the rate. Sinus tachycardia’s rate is 100–150 beats per minute. The rate for supraventricular tachycardia and paroxysmal supraventricular tachycardia is 150–250 beats per minute.

10. *Flip just the right side of page 117.* This rhythm is extremely dangerous: ventricular tachycardia. This is an ectopic focus in the ventricles gone wild. Immediate intervention is needed here. The patient may be stable and talking, unstable, or even pulseless.

11. *Flip just the right side of page 119.* This rhythm is torsades de pointes. Torsades is a rhythm that looks like ventricular tachycardia. It can last for a few seconds and may be well tolerated by the patient, but it can become life-threatening if sustained. Because the treatment is different for torsades than for ventricular tachycardia, differentiation between the two is important. Double-check when you see this pattern on an ECG to determine whether it is ventricular tachycardia or torsades.
12. *Flip just the right side of page 121*. This is *ventricular fibrillation*. The ventricles have become a “bag of worms.” This rhythm does not move any blood and does not produce a heartbeat. This patient will present in cardiac arrest. Immediate defibrillation is what is needed here, in an attempt to get the heart back into a coordinated rhythm.
13. **Flip just the right side of the page 123.**
   - Clue #1—the rate is 40–60 beats per minute.
   - Clue #2—the P waves are inverted (retrograde) or missing.

   This is a *junctional* or *nodal rhythm*. The rate produced by the junctional node is 40–60 beats per minute, and the conduction pattern is backward up through the atria and downward through the ventricles. We know there is retrograde conduction by looking at the upside-down P wave. If the P wave were absent, we would still call the rhythm *junctional* because it originated in the junction. There is also a rhythm known as *accelerated junctional*, which looks just like this one, with retrograde or absent P waves, but it is faster, above 60 beats per minute.
14. *Flip just the right side of page 125*. This is not a rhythm. This is asystole, the absence of electrical activity in the heart, and it indicates clinical death. Always remember to check the patient’s vital signs. The machine may not be “reading” the patient.

Heart Blocks

The next four rhythms represent delays or blockages in the electrical conduction system. See if you can determine where the blocks are occurring.

15. *Flip just the right side of page 127*. Compare the normal sinus rhythm tracing on the left to the one on the right. What looks different? The P-R interval is visually longer. In this first-degree heart block, there is a delay at the atrioventricular (AV) node, where the impulse becomes slowed. The normal P-R interval is 3–5 small boxes; the elongated one, 7–8 small boxes. At first glance, however, these rhythms look alike.

Do you think this is a dangerous rhythm?

No, it is not really dangerous by itself, but we might want to monitor the patient carefully to make sure that the impulses continue to get through. If they became blocked completely, instead of just delayed, it could become a serious condition.
16. *Flip just the right side of page 129.* This is another type of AV junction delay. Check your P-R intervals starting on the right-hand side at the third complex in. It gets longer and longer until it drops a QRS complex and a T wave. This rhythm is *second-degree heart block, Mobitz type I, or Wenckebach,* characterized by a P-R interval that gets progressively longer until the impulse is blocked, and just a lone P-wave appears. In this rhythm the P-waves stay at a steady rate while the QRS complex comes later and later until the conduction is blocked completely.

This rhythm is also characterized by a phenomenon called “group beating.” Group beating is seen by having a colleague hold the strip across the room. From a distance you will see groups of beats separated by what appears as blank space. Held at a distance across the room, this strip has group beating.
17. *Flip just the right side of page 131.* In second-degree heart block, Mobitz type II, some impulses are conducted normally while others are blocked. This can lead to a dangerous situation.

![Diagram of heart with SA node, AV node, and intermittent block labeled.]

18. *Flip just the right side of page 133.* This last actual rhythm is difficult to see and distinguish. It is called complete heart block. There is no relationship between the P waves and the QRS complexes. Every P wave is blocked.

![Diagram of heart with SA node, AV node, and block labeled.]

Atrial beats are normal, at a rate of 60–100 and are regular. The ventricles, which are not receiving any stimulation from the atria (because the impulse is blocked at the AV node), are beating at a normal ventricular rate of 20–40 beats per minute and are regular. The ventricular beats look wide and unusual because they are originating in the ventricles. This is known as third-degree or complete heart block.
19. *Flip just the right side of page 135.* This rhythm is an artificial pacemaker with capture. The spikes preceding each complex represent the pacemaker discharging and the electrical conduction system of the heart responding.

![Heart Diagram](image)

**Look-Alike Rhythms**
Place these rhythms next to each other for a demonstration of the differences:
1. Normal sinus rhythm and first-degree heart block.
2. Second-degree heart block, Mobitz type I, and second-degree heart block, Mobitz type II.
3. Sinus tachycardia and supraventricular tachycardia.
4. Atrial flutter and atrial fibrillation.

**Nonrhythms**
20. *Flip just the right side of page 137.* This rhythm has a wavy baseline but a regular R-R interval. You could compare it to atrial fibrillation by putting them side by side. This rhythm is actually a normal sinus rhythm with patient movement or a loose lead.
21. *Flip just the right side of page 139.* This is normal sinus rhythm with 60-cycle interference, such as that produced by static on a TV. Interference is generated inside the machine and can be resolved by moving away from the electrical current causing the interference.
Pulseless Electrical Activity

Excuse Me
What about pulseless electrical activity?

Answer:
Pulseless electrical activity (formerly known as electromechanical disassociation) is a condition in which you see a rhythm on the monitor, but the patient does not have a pulse. This can be caused by a variety of underlying medical emergencies that must be addressed immediately. These conditions include the following:

- Hypovolemia
- Hypoxia
- Cardiac tamponade
- Drug overdose
- Acidosis
- Tension pneumothorax

The treatment for pulseless electrical activity is as follows:
1. Cardiopulmonary resuscitation (CPR) should be initiated on all pulseless patients, regardless of the rhythm.
2. Advanced cardiac life support (ACLS) resuscitation should be initiated:
   - intubation, intravenous access, medication.
3. Investigate and treat underlying cause.
   
   Summary: This patient will have a visible electrical activity on the cardiac monitor but will not have a palpable pulse. This means that the heart’s electrical system is functioning but that there is a problem with other connected systems. There may be a mechanical pump problem, a vascular system problem, metabolic imbalance, or a drug overdose. These underlying problems have to be addressed for the resuscitation to be successful.
SUMMARY AND A FEW GOLDEN RULES

ECG monitor interpretation is a visual skill that is developed by practice and feedback. It is like going to work in a new office and learning the names of your co-workers. In the beginning it is hard; there may even be two people who look alike; often there is one person whose name you always forget. In a matter of days, you find that you can name one or two people; in weeks you can name more. Occasionally, you will get on the elevator with someone who works in the basement, and you’ll think, “I’ve never seen that woman before.” And so it is with ECG recognition. Some rhythms will start to look like old friends (especially the normal ones, because you breathe a sigh of relief when you see them). Some will cause you great anxiety. This book is designed to cover only the most basic rhythms.

Excuse Me
Are these rhythms from real people?

Answer:
Most of these are real rhythms taken from patients in the emergency department. Some rhythms are computer generated. There are two more real rhythms on p. 141-143; the first is a junctional rhythm, and the second is a normal sinus rhythm (with a rate of 100 beats per minute). Some variation is present, but you can easily recognize these rhythms. Some of the more unusual rhythms are not included in this book, and some of the regular rhythms have obscure presentations, but you’re off to a grand start. There are 100 more practice rhythms included on the CD as part of this text.
“All you had to do was follow the float with the pink cows! Was that so hard?!”

Arrhythmias can occur when electrical impulses are conducted in an unusual manner.
(From CLOSE TO HOME. Copyright John McPherson/Dist. of UNIVERSAL PRESS SYNDICATE. Reprinted with permission. All rights reserved.)

Question: What about the Q waves?

Answer: Thanks for asking. Q waves can be normal or pathologic (very bad), also known as “significant.” If they are one small box or wider and at least one third the height of the QRS complex, they signify that the patient has suffered a heart attack in the past. They are not an acute or immediate finding; they are telling us there was past damage to the heart. If Q waves do not meet those criteria, they are not usually significant.
GOLDEN RULES

1. Always treat the *patient*, not the monitor.
2. *Always* take a pulse and blood pressure.
3. Patients with an impending feeling of doom should be taken seriously.
4. *Don’t panic.* If the patient is talking to you, then you probably have a minute to think of what to do next. While you are thinking, give the patient some oxygen.
5. For patients in complete cardiac arrest, just follow your ACLS protocols (included at the back of the book).
6. It is harder to read a screen than to read a strip. If you are uncertain of the rhythm, run a strip and see if that helps.
7. Use *Cohn’s Pocket Guide to Adult ECG Interpretation*; it may help you to remember the name of a rhythm, and it is always handy to have a small ruler.
8. When faced with an unusual presentation (e.g., the rhythm does not match the clinical presentation of the patient), check the patient, the leads, and the monitor.
9. Intravenous lines are easier to start while the patient still has a blood pressure; try to get early intravenous access.
10. Ask for help if you need it. Request direction if you are unsure of what to do next. Make sure the pulse you feel belongs to the patient and is not your own.
In summary, in ECG interpretation rate and rhythm are what it is all about. (From CLOSE TO HOME. Copyright John McPherson/Dist. of UNIVERSAL PRESS SYNDICATE. Reprinted with permission. All rights reserved.)

You are now ready to begin reading ECGs. Feel free to collect your own ECG tracings, label them, and keep them tucked in this handbook to make your own advanced version of the text. Best of luck, and enjoy. Remember the old ECG blessing: As you go through life, may all your R waves land on a heavy line, and may your axis always be at 30 degrees.
Normal Sinus Rhythm

**Name:** Normal sinus rhythm (regular sinus rhythm)

**Description:**
- 60–100 beats per minute
- Each complex is complete: P wave, QRS complex, T wave.
- No untoward, wide, bizarre, ectopic, early, late, or different-looking complexes
- All intervals within normal limits

**Treatment:** Monitor vital signs; check blood pressure

**Questions:** SAMPLER

**Next Step:** Monitor patient’s condition.
**Sinus Arrhythmia**

**Name:** Sinus arrhythmia (normal variation)

**Description:**
- 60–100 beats per minute
- Each complex is complete: P wave, QRS complex, T wave.
- No untoward, wide, bizarre, ectopic, early, late, or different-looking complexes
- All intervals except the R-R are within normal limits.

**Treatment:** Monitor the vital signs.

**Questions:** SAMPLER

**Next Step:** Monitor the patient’s condition; sinus arrhythmia may be a variation caused by normal breathing or may be associated with diabetes or advanced age.
Sinus Bradycardia

**Name:** Sinus bradycardia (normal slow)

**Description:**
- Less than 60 beats per minute
- Each complex is complete: P wave, QRS complex, T wave.
- No untoward, wide, bizarre, ectopic, early, late, or different-looking complexes
- All intervals except the rate within normal limits

**Treatment:** Monitor the vital signs; check the blood pressure; this may be normal in the young and healthy. If the blood pressure is normal, no other treatment is required. If patient is hypotensive, “shocky,” cool or clammy, or has chest pain or a change in mental status, refer to the current ACLS guidelines at the back of this book.
**Questions:**  
SAMPLER. Do you take digitalis, propranolol, or quinidine?

**Next Step:**  
Consider acute myocardial infarction, digitalis toxicity, calcium channel blocker overdose, and electrical conduction system damage. Monitor blood pressure, check cardiac monitor for ectopic activity related to low heart rate, consider vasovagal response, and treat underlying cause.
Sinus Tachycardia

Name: Sinus tachycardia (normal fast)

Description:

- 100–160 beats per minute
- Each complex is complete: P wave, QRS complex, T wave. Note: P waves may be buried in the previous T wave.
- No untoward, wide, bizarre, ectopic, early, late, or different-looking complexes
- All intervals except the rate are within normal limits.

Treatment: Monitor the vital signs; check the blood pressure; treat the underlying condition.
Questions:  SAMPLER. Do you take digoxin?

Next Step:  Tachycardia can be caused by fear/anxiety, fever, hypoxia, shock, congestive heart failure, medications, pain, cocaine/crack, and blood loss. At very fast rates, the heart cannot refill fully, leading to reduced cardiac output. In the setting of ischemia, this hard work can further damage the heart muscle. See the ACLS guidelines at the back of this book.
Premature Atrial Contractions

**Name:** Premature atrial contractions (early ectopic atrial activity)

**Description:**
- Usually 60–100 beats per minute, but varies depending on the number of extra atrial beats that are created and conducted and the rate of the underlying rhythm.
- *Premature atrial contractions are ectopic beats that occur in the context of other rhythms.*
- Each complex is complete: P wave, QRS complex, T wave. The early P waves look different from the normal P waves. These early P waves may be smaller or peaked. The QRS complex may be normal or conducted differently. P-R intervals may vary (usually shorter), depending on the distance from the ectopic foci to the AV node. The R-R interval varies at the ectopic complex.
**Treatment:** Monitor the vital signs; watch for change in the rhythm. No other treatment is necessary.

**Questions:** SAMPLER

**Next Step:** Premature atrial contractions may be a normal variation.
Premature Ventricular Contractions

Name: Premature ventricular contractions (early ectopic ventricular complexes)

Description: The rate depends on underlying rhythm. Do not count the premature ventricular contractions.

- Premature ventricular contractions are ectopic beats that occur in the context of other rhythms. Premature ventricular contractions are not a rhythm themselves.

- The premature ventricular contraction is an untoward, wide, bizarre, early, and different-looking complex. If there is just one ectopic focus, the premature ventricular contraction is called unifocal, and each one looks the same. If there is more than one ectopic focus, the premature ventricular contractions are called multifocal and vary in appearance.
Intervals may be irregular owing to the premature complexes and compensatory pauses. No P waves are present before the premature ventricular contraction.

**Treatment:** Monitor the vital signs, and check the blood pressure. *Occasional* premature ventricular contractions with no symptoms require no treatment. Premature ventricular contractions in the presence of acute myocardial infarction/chest pain; frequent multifocal or unifocal premature ventricular contractions, greater than six per minute; or back-to-back premature ventricular contractions require management with medication.

**Questions:** SAMPLER/OPQRST-I

**Next Step:** Monitor patient’s condition. Watch the monitor for runs of premature ventricular contractions or a change in rhythm.
**Atrial Flutter**

**Name:** Atrial flutter (F waves) (very rapid atrial rate; think of atrial fluuuuuutter)

**Description:**

- Atrial flutter is a fast, constant firing of an ectopic focus.
- The *atrial* rate is very fast, 240–360 beats per minute.
- Instead of P waves, atrial flutter has F waves.
- The *ventricular* rate depends on the conduction ratio, 2:1, 3:1, 4:1, usually 60–100 beats per minute.
- The complexes are incomplete. They start with F waves as a baseline: F wave, F wave, QRS complex, F wave (with T wave buried in the F wave), F wave.
Baseline consists of constant F waves and intermittently conducted QRS complexes, and if you turn the rhythm strip upside down, it is thought to resemble a sawtooth pattern.

Intervals cannot be measured because there is no P wave. QRS complexes are usually within normal limits. T waves usually cannot be seen.

**Treatment:** Hemodynamically stable patients (no signs of shock) require no initial treatment. If ventricular (QRS) rate is rapid, 120–140 beats per minute, monitor the vital signs; check the blood pressure. Follow ACLS guidelines.

**Questions:** SAMPLER/OPQRST-I.

**Next Step:** Monitor the patient’s condition; perform frequent blood pressure and rhythm checks.
Atrial Fibrillation

Name: Atrial fibrillation (f waves) (uncoordinated, fast atrial activity)

Description: Atrial rate appears as the baseline, 350–600 beats per minute. May be coarse (and able to be counted) or so fine they appear too small to count. There are no P waves; instead atrial fibrillation has f waves, known as fibrillatory waves.

Ventricular rate is 100–160 beats per minute. R-R interval is always irregular because of chaotic constant stimulation from the atria.

Baseline is all f waves, with QRS complexes usually within normal limits.
Treatment: In the hemodynamically stable patient, no treatment is required. This may be normal for elderly patients. In the unstable patient (syncope, signs/symptoms of shock), monitor vital signs and check blood pressure. Follow ACLS guidelines.

Questions: SAMPLER/OPQRST-I. Do you have chest pain? Do you take digoxin, verapamil, or propranolol?

Next Step: Atrial fibrillation can lead to reduced cardiac output of up to 20% and an increased danger of clot formation from poor atrial emptying.
Supraventricular Tachycardia

**Name:** Supraventricular tachycardia (paroxysmal supraventricular tachycardia) (fast rate from a pacemaker site above the ventricles)

**Description:**
- 160–250 beats per minute
- Each complex is complete: P wave, QRS complex, T wave, P waves may be absent or may be buried in the preceding complex.
- No untoward, wide, bizarre, ectopic, late, or different-looking beats except for P waves that may be absent or abnormal

The QRS complex and the T wave are within normal limits. Rate is very fast.

**Treatment:** Monitor the vital signs; check the blood pressure. Consider vagal maneuvers, drug intervention, cardioversion. Follow ACLS guidelines included in this book.

**Questions:** SAMPLER/OPQRST-I. Listen to lung sounds.

**Next Step:** Monitor patient for congestive heart failure, signs/symptoms of shock.
Ventricular Tachycardia

Name: Ventricular tachycardia (rapid deadly rhythm of the ventricles)

Description:
- 100–250 beats per minute
- Only wide, tall, bizarre-looking complexes
- QRS complex greater than 0.12 second, wide, weird-looking

Treatment: **THIS IS/CAN BE A DEADLY RHYTHM.** The ventricles cannot maintain this rate. Monitor vital signs; check blood pressure. If patient is awake and alert with adequate vital signs, give medications consistent with ACLS guidelines at the back of this book.

Questions: MONITOR ABCs. SAMPLER.

Next Step: Ask how long has patient been like this. Monitor; intravenous access; defibrillation pads; CPR; prepare for cardiac arrest.
Torsades de Pointes

Name: Torsades de pointes

Description:  
♥ 150 beats a minute or greater  
♥ Wide complexes that twist over themselves  
♥ Often preceded by a prolonged QT interval

Treatment: THIS CAN BE A DEADLY RHYTHM. This rhythm can result from a prolonged QT resulting from medications or disease. If the patient has a pulse, support vital signs and consider a pacemaker or magnesium sulfate. Follow ACLS guidelines. If the patient has no pulse, begin CPR and follow the guidelines for ventricular fibrillation.

Questions: SAMPLER.

Next Step: Monitor, intravenous access, pacemaker, defibrillation pads, CPR; prepare for cardiac arrest
Ventricular Fibrillation

**Name:** Ventricular fibrillation; this is a rapid, uncoordinated firing of the ventricles, like a “bag of worms.”

**Description:**
- THIS IS A DEADLY RHYTHM.
- This rhythm does not generate a pulse.
- Completely uncoordinated electrical activity without any discernible complexes
- All waves are f waves (fibrillatory waves).

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Treatment: Quickly check the pulse. If no pulse is present, defibrillate immediately. CPR/intravenous line/ACLS protocol at the back of this book.

Questions: How long has patient been like this? SAMPLER

Next Step: Intubation; CPR; intravenous access
Junctional (Nodal) Rhythm

Name: Junctional (nodal) rhythm (originating in the AV junction)

Description: ♥ Usually 40–60 beats per minute, the intrinsic rate of the AV node

♥ No preceding P-waves because the impulse is generated in AV node. Occasionally, the P-waves have a retrograde conduction (deflected downward) either before or after the QRS complex.

♥ The QRS complex and the T wave are usually normal.

♥ NOTE: Accelerated junctional rhythms meet the above criteria but are at a rate of 60–100 beats per minute.
Treatment: Monitor vital signs. If vital signs and patient are stable, treat underlying cause: myocardial infarction, congestive heart failure, acidosis, hyperkalemia. Establish intravenous access; prepare pacemaker.

Questions: SAMPLER/OPQRST-I. Medications?

Next Step: Carefully monitor vital signs and mental status. Keep pacemaker and medications nearby.
Asystole

**Name:** Asystole (cardiac standstill/flat line)

**Description:**
- **This rhythm is associated with death.**
- **No pulse**
- Less than 5 beats per minute
- ECG shows an underlying asystole with occasional agonal beats.
- No complexes are associated with this rhythm.

Treatment: Quickly check vital signs; CPR
Questions: How long has patient been like this?
Next Step: Intubate, resuscitate, transport/transfer to ED/CCU, or pronounce patient dead.
First-Degree AV Heart Block

Name: First-degree AV heart block (elongated P-R interval)

Description:
♣ 60–100 beats per minute

♣ Each complex is complete: a P-wave, a QRS complex, and a T wave.

♣ No untoward, wide, bizarre, ectopic, early, late, or different-looking beats

♣ All intervals are within normal limits, **EXCEPT** the **P-R interval** is greater than 0.20 second (or five small boxes)

♣ **Note:** This rhythm looks just like normal sinus rhythm except that it has an elongated P-R interval. Flip to normal sinus rhythm to compare rhythms.
First-degree AV heart block is a slowing at the AV node, creating a prolonged P-R interval. It may be caused by damage to the junction, increased vagal tone, or drug toxicity.

**Treatment:** Monitor vital signs, and check blood pressure. If patient is stable, no treatment is indicated.

**Questions:** SAMPLER/OPQRST-I.

**Next Step:** Monitor patient’s condition, and watch for further deterioration of rhythm.
Second-Degree Heart Block, Mobitz Type I (Wenckebach)

Name: Second-degree heart block, Mobitz type I (Wenckebach) (progressive lengthening of the P-R interval)

Description: ~ 60–100 beats per minute

- Almost every complex is complete: a P-wave, a QRS complex, and a T wave, except some P-waves are not followed by a QRS complex or a T wave because the impulse was blocked.

- No untoward, wide, bizarre, ectopic, early, or different-looking complexes

- The P-R interval becomes longer and longer until the impulse is not conducted at all and the QRS complex and the T wave are missing. P--QRS--T, P----QRS--T,
P-------QRS--T, P-------------. P--QRS--T. After the beat is dropped, the P-R interval returns to normal. Strip shows “group beating” complexes. This strip has two groups of three. All other intervals are within normal limits.

**Treatment:** Monitor vital signs and blood pressure; if rate is below 60 beats per minute or vital signs are unstable, treat the bradycardia.

**Questions:** SAMPLER/OPQRST-I

**Next Step:** Monitor patient’s condition.
Second-Degree Heart Block, Mobitz Type II

**Name:** Second-degree heart block, Mobitz type II (some impulses are conducted normally, and others are blocked)

**Description:**
- 30–100 beats per minute depending on the ratio of conduction: 2:1, 3:1, 4:1
- *Almost every complex is complete:* a P-wave, a QRS complex, and a T wave, except some P-waves are not followed by a QRS complex or a T wave because the impulse is blocked.
- Impulses are blocked at the AV node so that some P-waves stand alone. In type II heart block, the P-R interval is constant and normal.
- No untoward, wide, bizarre, ectopic, early, late, or different-looking complexes
- All intervals except R-R are normal.
- Mobitz type II beats conduct in a ratio: 1:1, 2:1, 3:1, or 4:1.

**Treatment:** Monitor vital signs; check blood pressure. If vital signs are stable; no treatment is indicated. Treatment is indicated if bradycardia persists or is symptomatic.

**Questions:** SAMPLER/OPQRST-I

**Next Step:** Watch the patient, and monitor for further deterioration.
Third-Degree AV Heart Block: Complete Heart Block

Name: Third-degree AV heart block: complete heart block (no relationship between the P-waves and QRS complexes)

Description: The AV node is completely blocked. There is no relationship between the P-wave and the QRS complex and T wave.

- P-wave (atrial) rate 60–100 beats per minute
- QRS complex (ventricular rate 20–40 beats per minute). T waves follow QRS complexes.
- QRS complexes may look narrow if the impulses originate from the junction, or wide and bizarre if the ventricle is initiating the impulses.
- P-R interval varies because it is completely random and unrelated to QRS complex.
Treatment: Monitor the vital signs; check the blood pressure; only ventricular beats produce a pulse. The blood pressure may be low. The cardiac output may be compromised. If there are signs/symptoms of shock, give atropine. Do NOT give lidocaine. Consider a pacemaker.

Questions: SAMPLER/OPQRST-I

Next Step: Carefully monitor patient until successfully medicated or paced.
Pacemaker Rhythm

**Name:** Pacemaker rhythm (cardiac pacemakers deliver an electrical stimulus to the heart, causing electronic depolarization and subsequent cardiac contraction)

**Description:** Pacemakers can be transcutaneous (through the skin), transvenous (tip of the venous catheter in the right ventricle or right atrium, or both), transthoracic (through the anterior chest wall into the heart), epicardial (on the surface of the heart), or “permanent” (wires surgically implanted in the heart, with batteries in a box usually under the collar bone).
Occasionally, they are used with severe tachycardia; this is called overdrive pacing. They can act as the primary pacemaker, or they can be set to activate if the heart rate drops below a preset number (demand).

- On ECG they appear as straight, hard, vertical lines known as pacemaker spikes, each followed by a QRS complex and T wave (which may or may not look normal).

- P-waves may be absent or present, and they may or may not be associated with the QRS complexes.

- Capture (an electrical event) is achieved when each pacemaker spike is followed by a QRS complex and T wave. Patients should always be assessed by taking a pulse and blood pressure.

**Treatment:** Monitor the vital signs; check the pulse and blood pressure frequently. Notify cardiology of the need for a permanent pacemaker. Treat underlying rhythm (i.e., bradycardia, tachycardia, or complete heart block).

**Questions:** SAMPLER/OPQRST-I. Do you have a pacemaker? Where is it located? How long have you had this pacemaker?

**Next Step:** Carefully monitor patient until successfully stabilized.
Loose Lead/Cable Movement

**Name:** Loose lead/cable movement (artifact produced by extra movement of one or more of the electrodes)

**Description:** This occurs with improperly applied electrodes; loose, disconnected, or reversed leads or cables; inadequate electrode paste; oily skin; chest hair; excessive sweating or shivering; patient movement; muscle tremor; heavy or rapid breathing; a bumpy ambulance ride; use of other electric equipment around the monitor; and a variety of other factors can produce artifacts in the ECG, some of which bear an alarming resemblance to life-threatening dysrhythmias. An artifact can appear on a strip with any underlying rhythm. P-waves, QRS complexes, and T waves are dependent on the underlying rhythm.
Treatment: Check the pulse and the blood pressure. Check the electrodes and cables for disconnection, placement over a bony prominence, chest hair, diaphoresis, inadequate contact, and placement. If patient is diaphoretic, use diaphoretic leads; if pediatric patient, use pediatric leads appropriate to patient’s size.

Questions: None

Next Step: Change cables, monitor, or leads, as appropriate.
60-Cycle Interference

**Name:** 60-cycle interference

**Description:** This artifact is produced by electrical interference caused by a source of alternating current. 60-cycle is AC interference. The P-waves, QRS complexes, and T waves reflect the underlying rhythm.

**Treatment:** Move the cables away from the source of the interference.

**Questions:** None

**Next Step:** None
Junctional Rhythm with Rate of 40 Beats per Minute

Name: Junctional (nodal) rhythm (originating in the AV junction)

Description: ♥ Usually 40–60 beats per minute, the intrinsic rate of the AV node

♥ No preceding P-waves because the impulse is generated in the AV node. Occasionally, P-waves have retrograde conduction (deflected downward) either before or after the QRS complex.

♥ QRS complex and T wave usually normal

Treatment: Monitor the vital signs. If the vital signs and the patient are stable, treat the underlying cause: myocardial infarction, congestive heart failure, acidosis, hyperkalemia. Establish intravenous access; prepare pacemaker.
Questions:  SAMPLER/OPQRST-I. Medications?

Next Step:  Carefully monitor vital signs and mental status. Keep pacemaker and medications nearby.
Normal Sinus Rhythm with Rate of 100 Beats Per Minute

Name: Normal sinus rhythm (regular sinus rhythm)
Description: 60–100 beats per minute
- Each complex is complete: P-wave, QRS complex, T wave.
- No untoward, wide, bizarre, ectopic, early, late, or different-looking complexes
- All intervals within normal limits
Treatment: Monitor the vital signs; check the blood pressure
Questions: SAMPLER
Next Step: Monitor patient’s condition.
ADULT BRADYCARDIA
(With Pulse)

1. Assess appropriateness for clinical condition. Heart rate typically <50/min if bradyarrhythmia.

2. Identify and treat underlying cause
   - Maintain patent airway; assist breathing as necessary
   - Oxygen (if hypoxemic)
   - Cardiac monitor to identify rhythm; monitor blood pressure and oximetry
   - IV access
   - 12-Lead ECG if available; don’t delay therapy

3. Persistent bradyarrhythmia causing:
   - Hypotension?
   - Acutely altered mental status?
   - Signs of shock?
   - Ischemic chest discomfort?
   - Acute heart failure?

4. Monitor and observe
   - No

5. Atropine
   - If atropine ineffective:
     - Transcutaneous pacing OR
     - Dopamine infusion OR
     - Epinephrine infusion

6. Consider:
   - Expert consultation
   - Transvenous pacing

Doses/Details
Atropine IV Dose:
First dose: 0.5 mg bolus
Repeat every 3-5 minutes
Maximum: 3 mg

Dopamine IV Infusion:
2-10 mcg/kg per minute

Epinephrine IV Infusion:
2-10 mcg per minute

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ADULT TACHYCARDIA
(With Pulse)

1. Assess appropriateness for clinical condition. Heart rate typically ≥150/min if tachyarrhythmia.

2. Identify and treat underlying cause
   • Maintain patent airway; assist breathing as necessary
   • Oxygen (if hypoxemic)
   • Cardiac monitor to identify rhythm; monitor blood pressure and oximetry

3. Persistent tachyarrhythmia causing:
   • Hypotension?
   • Acutely altered mental status?
   • Signs of shock?
   • Ischemic chest discomfort?
   • Acute heart failure?

4. Synchronized cardioversion
   • Consider sedation
   • If regular narrow complex, consider adenosine

5. Wide QRS? ≥0.12 second
   6. No
   7. Yes

6. Yes
   • IV access and 12-lead ECG if available
   • Consider adenosine only if regular and monomorphic
   • Consider antiarrhythmic infusion
   • Consider expert consultation

Doses/Details

Synchronized Cardioversion
Initial recommended doses:
• Narrow regular: 50-100 J
• Narrow irregular: 120-200 J biphasic or 200 J monophasic
• Wide regular: 100 J
• Wide irregular: defibrillation dose (NOT synchronized)

Adenosine IV Dose:
First dose: 6 mg rapid IV push; follow with NS flush. Second dose: 12 mg if required.

Antiarrhythmic Infusions for Stable Wide-QRS Tachycardia

Procainamide IV Dose:
Initial recommended doses:
20-50 mg/min until arrhythmia suppressed, hypotension ensues, QRS duration increases >50%, or maximum dose 17 mg/kg given. Maintenance infusion: 1-4 mg/min. Avoid if prolonged QT or CHF.

Amiodarone IV Dose:
First dose: 150 mg over 10 minutes. Repeat as needed if VT recurs. Follow by maintenance infusion of 1 mg/min for first 6 hours.

Sotalol IV Dose:
100 mg (1.5 mg/kg) over 5 minutes. Avoid if prolonged QT.

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GLOSSARY

ABC. The abbreviation for airway, breathing, circulation. The first three steps of basic life support.

absolute refractory The early phase of cardiac repolarization in which the heart muscle cannot be stimulated to depolarize.

acidosis A disturbance in the acid-base balance of the body; an excess of acid.

ACLS Advanced Cardiac Life Support. A series of protocols and standards set by the American Heart Association for the resuscitation and treatment of cardiac patients.

agonal rhythm Cardiac rhythm seen just before asystole, associated with infrequent wide QRS complexes and no cardiac output or pulse.

AMI Acute myocardial infarction, a heart attack.

anatomical position The position of a patient who is upright, facing forward, hands by sides with palms facing forward.

antiarrhythmic drug Any drug given to prevent or terminate cardiac dysrhythmias.

APE Acute pulmonary edema; left-sided congestive heart failure.

apical pulse A pulse taken by listening over the apical portion of the heart for 60 seconds.

arrhythmia Any deviation from the normal rhythm of the heart.

atria The two top chambers of the heart.

atrial depolarization Electrical process resulting in atrial contraction, represented by the P-wave on the ECG.

atrial fibrillation A dysrhythmia characterized by multiple rapid ectopic atrial foci and an irregular ventricular response.

atrial flutter A dysrhythmia characterized by a single, rapid, ectopic atrial focus resulting in a sawtooth pattern on the ECG, as the AV node conducts impulses in a set pattern (e.g., 3:1, 4:1).

atropine A drug used to increase the speed of the heart by blocking the parasympathetic nervous system.

AV node Atrioventricular node. Portion of the cardiac conduction system that conducts impulses from the atria.

baseline Isoelectric line of the ECG.

biphasic An ECG complex that is located half above and half below the isoelectric line.

blocked impulse An electrical impulse that is stopped or slowed at a certain point and not conducted further through the system.

b/p Blood pressure.
bpm  Beats per minute.

brady-  Prefix meaning slow.

bradycardia  Slow heart rate, under 60 beats per minute.

bundle branches  The portion of the conduction system of the heart that conducts impulses from the bundle of His to the Purkinje fibers and works to contract the ventricles.

bundle of His  The portion of the conduction system of the heart that conducts impulses from the AV node to the bundle branches and works to contract the ventricles.

CaCl  Calcium chloride.

cardia(o)-  Prefix pertaining to the heart.

cardiac arrest  The sudden cessation of cardiac activity.

cardiac cycle  The period from one cardiac contraction to the next.

cardiac output  Stroke volume × heart rate.

cardioversion  Application of a synchronized electrical current to restore the heart’s conduction system to a normal rhythm or function.

CHF  Congestive heart failure. Failure of adequate ventricular function, which results in the back-up of blood or fluid.

coarse V-fib  The uncoordinated beating of many weak ectopic ventricular foci, which results in a squiggly line on the ECG. Illustrates possibly viable electrical activity in the heart.

code  A signal used to summon a team of medical professionals trained to administer CPR/ACLS to a patient in cardiac arrest.

compensatory pause  A change in the R-R interval that follows a premature or delayed beat and restores the original rhythm.

complexes  Waveform made on the ECG tracing, representing electrical conduction throughout the heart. Can refer to the QRS complex (contraction of the ventricles) or the entire sequence (P-QRS-T), as in the number of complexes in 1 minute.

conduction  The ability of the electrical system of the heart to transmit impulses from cell to cell.

contraction  The shortening of a muscle, in this case the heart.

coronary arteries  The arteries that supply blood to the heart muscle.

CPR  Cardiopulmonary resuscitation. Ventilation combined with external chest compressions provided to patients in cardiac arrest.

defib pads/paddles  Large pads or paddles attached to a defibrillator, used to deliver an electrical shock to a patient.

defibrillation  Application of an unsynchronized electrical shock in an effort to restore a normal cardiac rhythm.
**defibrillator**  A device that is used to deliver strong electrical current to restore regular rhythms from uncoordinated ones.

**deflection**  The direction of a complex on the ECG in relation to the isoelectric line. Deflected upward (above) or downward (below) relative to the baseline.

**depolarization**  The conduction of an impulse through the myocardium when the cells go from negatively charged to positively charged.

**diastolic**  Pertaining to the relaxation phase of the heart.

**digoxin**  Lanoxin, a medication given to regulate a rapid heart rate.

**dropped beats**  Cardiac impulses created by a pacemaker but not conducted through the electrical system. They usually appear as a lone P-wave on the ECG strip not followed by a QRS complex or a T wave.

**drug toxicity**  Having in excess of the therapeutic level of a medication in the blood.

**ECG**  Electrocardiogram; also abbreviated as *EKG*. The electrical activity of the heart displayed on a screen or recorded on paper.

**ectopic**  Located away from a normal position. For instance, an ectopic complex is an impulse generated from cells outside the usual pacemaker sites.

**Einthoven**  Inventor of the ECG machine.

**EKG**  Electrocardiogram; also abbreviated as *ECG*. See *ECG*.

**electrodes**  Small pads placed on the chest wall that convert the electrical activity of the heart to a dynamic display on a monitor.

**f waves**  The fibrillatory waves of atrial fibrillation. Frequent irregular waves caused by multiple weak ectopic foci.

**F waves**  Flutter waves of atrial flutter. The repetitive, rapid, regular beating of one irritable focus in the atrium characterized by a sawtooth pattern on ECG.

**fever**  A temperature above 98.6 °F or 37 °C.

**focus**  One cell generating electrical activity that originates outside a usual pacemaker site. (Plural: *foci*.)

**hemodynamic**  The force involved in circulating the blood through the body.

**hyperkalemia**  Excessive amount of potassium in the blood.

**hypotension**  Low blood pressure.

**hypoxia**  Diminished amount of oxygen in the tissues, usually the result of inadequate respirations.

**Inderal**  Propranolol, a beta blocker used to slow the heart rate and control irregular rhythms.

**intrinsic**  Inherent or inborn, from within.
intubate  Insert a tube into the trachea to secure an airway.

irregular  When the measure of the R-R interval varies in an ECG rhythm.

ischemia  Muscle tissue damaged from lack of oxygen in the heart; the damaged part of the heart muscle does not respond to electrical stimuli in the same way healthy muscle does, resulting in arrhythmias.

isoelectric line  An imaginary line that is the baseline of ECGs. It is where the complexes begin and end, and the P-R interval usually rests on it.

IV  Intravenous.

junctonal impulses  Impulses originating in the AV node, or the AV junction.

large box  On the ECG paper, one large box is made up of five small boxes and is equivalent to 0.20 second.

lidocaine  An antiarrhythmic medication given to reduce ectopic activity.

MI  Myocardial infarction.

mm  Millimeter.

monitor  The screen on which ECG rhythms are viewed.

multifocal  Originating from more than one ectopic pacemaker site.

myocardium  The muscle cells of the heart.

nodal  Originating in the AV node.

node  The name of a part of the electrical conduction system of the heart (i.e., SA node, AV node).

OPQRST-I  (1) Alphabetical name of the waves of the ECG developed by Einthoven. (2) Abbreviation for onset, provokes, quality, radiation, severity, time, interventions. A memory system for assessing chest pain.

P-wave  The graphic representation of the depolarization of the atria on the ECG.

PAC  Premature atrial contraction.

paced rhythm  A cardiac rhythm created by an artificial pacemaker placed in the heart.

pacemaker  (1) Specialized tissue within the heart that initiates electrical activity and causes the heart to contract. (2) A battery-powered device, placed in the heart, designed to sense a decrease in cardiac activity and create electrical activity, causing the heart to contract in the absence of intrinsic pacemaker activity.

paroxysmal  Sudden and intense occurrence of symptoms.

P-R interval  The interval measured from the beginning of the P-wave to the beginning of the R-wave; should be no more than 0.12–0.20 second or three to five small boxes, and represents the path of the impulse through the atria and AV junction.
**precordial thump**  Procedure used for witnessed cardiac arrest in which the rescuer uses a closed fist to strike a patient over the sternum in an effort to restore cardiac activity.

**premature**  Arriving earlier than expected.

**primary pacemaker**  SA node of the heart; located highest in the heart and having the fastest intrinsic firing rate.

**Pt**  Patient.

**Purkinje fibers**  Portion of the heart’s conduction system that helps to contract the ventricles.

**PVC**  Premature ventricular contraction.

**QRS complex**  The graphic representation of the depolarization of the ventricles on ECG.

**quinidine**  An antiarrhythmic medication used to slow conduction.

**ratio**  Conduction of impulses in a pattern (e.g., 3:1, 4:1, 5:1).

**refractory**  The repolarization stage of the heart.

**regular**  A constant R-R interval throughout a rhythm strip.

**relative refractory**  The period of time during repolarization when the heart is still susceptible to strong stimulus.

**repolarization**  Relaxation phase of the myocardium.

**retrograde**  Backward conduction of an impulse, upward through the heart instead of downward.

**r/o**  Rule out.

**R-R interval**  The measured distance between two R waves. This distance should be constant throughout the rhythm strip for the rhythm to be considered regular.

**r/t**  Related to.

**SA node**  Sinoatrial node, the primary pacemaker of the heart. Highest in location, and fastest in intrinsic firing rate.

**SAMPLER**  Acronym for *signs and symptoms, allergies, medications, past history, last meal, events leading to, risk factors*. A memory system for patient history.

**septum**  Cartilage tissue that divides the heart into left and right halves.

**shock**  Inadequate tissue perfusion.

**sign**  Clinical indicator that you can see or measure.

**sinus**  Normal.

**sinus rhythm**  Normal, regular cardiac rhythm.

**small box**  Representation on ECG paper of 0.04 second.
S/5  Signs and symptoms.

sternum  The bone that lies in the center of the chest, the breastbone.

symptom  Clinical indicator that the patient reports. See sign.

symptomatic  Showing clinical indicators of a condition (e.g., symptomatic bradycardia is a slow heartbeat accompanied by dizziness and weakness).

syncope  Fainting.

systole  The part of the cardiac cycle that represents the heart contracting and pushing blood out to the lungs and body.

T wave  The waveform on the ECG that represents the repolarization of the ventricles of the heart.

tachy-  Prefix meaning fast.

tachycardia  A fast heart rate, above 100 beats per minute.

tx  Treatment.

uncoordinated  Cells in the heart firing electrical activity at different times, resulting in no true contraction of the heart muscle. The heart looks like a “bag of worms.”

unifocal  Electrical activity originating from one irritable cell in the heart, not a primary pacemaker.

untoward  Unexpected.

vagal maneuvers  Physical actions designed to stimulate the vagus nerve and slow down rapid heart rates, such as bearing down as if to have a bowel movement, performing carotid sinus massage, or pressing on both eyes.

vagal tone  Pertaining to innervation of the tenth cranial nerve, the vagus nerve, which is the chief mediator of the parasympathetic nervous system. Stimulation of this nerve slows down heart rate.

vasovagal  Usually used to refer to a syndrome in which a patient accidentally stimulates the vagus nerve (e.g., by bearing down to have a bowel movement, resulting in a slowed heart rate and an episode of syncope).

ventricles  The two lower chambers of the heart.

ventricular fibrillation  Weak, rapid, disorganized discharge of multiple ventricular ectopic foci resulting in a squiggly line on the ECG. It may appear coarse or fine.

v/s  Vital signs.
1. **What is the rate?**
   - [ ] 0–60 bpm
   - [ ] 60–100 bpm
   - [ ] 100–300 bpm

2. **Is each complex complete?**
   
   Does it contain:
   - [ ] P-wave
   - [ ] QRS complex
   - [ ] T wave

3. **Is the rhythm R-R interval constant?**
   (peak of the R wave to peak of the R wave)
   - [ ] yes
   - [ ] no

4. **Does any complex look wildly abnormal?**
   - [ ] Elongated, irregular P-R intervals
   - [ ] or P, F, or f waves for a baseline
   - [ ] Wide, bizarre, or notched QRS complexes?
   - [ ] P or T waves deflected downward or elevated?

5. **Name the rhythm:**

   *If the rate is below 60 consider:*
   - Sinus bradycardia
   - Junctional rhythm
   - Ventricular fibrillation
   - Asystole
   - Premature ventricular complexes
   - Third degree/complete heart block

   *If the rate is 60–100 consider:*
   - First degree heart block
   - Second degree heart block I & II
   - Accelerated junctional rhythm (has no P waves)
   - Atrial fibrillation
   - Atrial flutter
   - Premature atrial complexes

   *If the rate is above 100 consider:*
   - Sinus tachycardia
   - Supraventricular tachycardia
   - Atrial fibrillation
   - Atrial flutter
   - Ventricular tachycardia
   - Torsades de Pointes

Criteria for a normal ECG:

one small box– 0.04 second
one large box– 0.20 second

P wave– 3 small boxes
or 0.12 second wide

P-R interval– 3–5 small boxes
or 0.12–0.20 second wide; elongation means
slowed conduction; consider heart blocks

QRS complex– 1–2½ small boxes
or 0.04–0.10 second wide

T wave– upright, well rounded, and
less than half the height of the QRS complex

The first step in all patients is to check the pulse.
Treat the patient, not the monitor.

Place strip here for comparison

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THE PEDIATRIC AND NEONATAL PATIENT

I am in the emergency department at the crib of an infant in cardiac arrest caused by a near drowning. Too many people with large hands are trying to work on this tiny body. We can’t find room for everything we need to do: We can’t find a space on the chest for the monitor leads because the pediatric paddles are taking up all the space. Our “quick look” heart rate is only 36 beats per minute. We have her on 100% oxygen. We are frantically trying to get an intravenous access. I am almost finished drawing up premeasured medications into tiny syringes so that we will be ready. My back is to the cardiac monitor when her heart rate starts to pick up. I can hear the bleeps, coming faster now, sounds like 60, then 70, then 80. I turn to look, and the team looks with me. “She’s back,” someone says. Then she starts to cry.

Having mastered the basics of ECG interpretation, you will find that you can adapt the same principles to the pediatric patient. The complex names and locations are the same: the P-wave, QRS complex, and T-wave. The parameters are changed to reflect the range of “normal” for the pediatric and neonatal patient. In pediatrics, the doses are age and weight based, so there are ranges of normal for each group.

The primary cause of abnormal rhythms in the adult population is coronary artery disease and heart attacks (acute myocardial infarction), whereas respiratory distress is the most common cause of irregular heart rhythms in the pediatric population. This is due to the general state of the child’s or infant’s coronary arteries. They have not lived long enough to have developed coronary artery disease.

Answer:
In children the causes fall into two categories:
- Congenital or inborn conditions in which the heart has not developed normally. This includes children born with transposition of the great vessels, open holes in the ventricular septum, and alternative pathways of conduction. These do not usually present as an emergency situation but do have unusual-looking ECG tracings.
Conditions in which the heart is trying to compensate for an acute illness or injury. These include dehydration, drowning, low oxygen states (hypoxia), high fever, fear, head injury, loss of blood volume (hypovolemia), drug overdose, metabolic disorders, and systemic illness.

PEDIATRIC RHYTHM INTERPRETATION

In pediatric interpretation we are less concerned with naming the rhythm and we become more interested in two basic questions:
1. Does the child look sick or well?
2. Does the rhythm look fast or slow, or is there no pulse?

How Does the Child Look?
We want to start by looking at the patient, not the monitor. If children look sick, they need immediate intervention. Sick children are pale; have rapid respirations, flaccid muscle tone, and nasal flaring; and use their accessory muscles to breathe.
Extremely sick infants can neither take a bottle nor recognize their parents. As the work of breathing becomes more difficult, without intervention the child will tire and the heart rate and respiratory rates decline.

Children who look sick require immediate and effective airway management, supplemental oxygenation, intravenous fluids, and electrolyte correction. Addressing the low oxygen states and recognizing and treating the underlying cause are really the keys to successful resuscitation in the pediatric population.

Does the Rhythm Look Fast or Slow, or Is There no Pulse?
In the case of children, we emphasize the early recognition of categories of rhythms rather than specific diagnoses of rhythms.

We are simply asking the following question: Is the abnormal rhythm associated with a change in the child’s condition?

THE DEFINITION OF PEDIATRIC PATIENTS

Pediatric patients are divided into four groups:
♥ The newly born—from the first minutes to the first hours of life
♥ The neonate—from the first hours of life to the first 28 days
♥ The infant—28 days to 1 year
♥ The child—1 year to 8 years of age

Pediatric patients share some basic anatomical similarities; specifically, their airways are narrow and, most important to resuscitative efforts, their head should not be hyperextended because this can restrict their air passage and exacerbate the preexisting arrhythmia caused by hypoxemia. Intubations in pediatric patients are performed using an uncuffed endotracheal tube because of a narrowed area of the cricoid cartilage and the ability of the soft tissue in the subglottic space to produce a natural seal.

DEFINITIONS

Normal
The normal range of heart rates in pediatrics is variable and changes based on age. On pediatric ECGs bradycardia is defined as a heart rate below the second percentile of normal for that age and tachycardia as a heart rate greater than the ninety-eighth
percentile of normal for that age when awake. Because of these types of definitions, it is difficult to set hard and fast rules as to complex widths and intervals. For monitor interpretation an ECG that contains a P-wave, a QRS complex (normal for age and less than or equal to 0.08 second), and a T-wave is considered normal.

Table 1 shows the normal ranges for children.

Table 1. Pediatric Normal Heart Rates

<table>
<thead>
<tr>
<th>Age of Child</th>
<th>Beats Per Minute (resting, awake)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month – 1 year old</td>
<td>100–160</td>
</tr>
<tr>
<td>1–3 years old</td>
<td>90–150</td>
</tr>
<tr>
<td>4–5 years old</td>
<td>80–140</td>
</tr>
<tr>
<td>6–12 years old</td>
<td>70–120</td>
</tr>
<tr>
<td>13–18 years old</td>
<td>60–100</td>
</tr>
</tbody>
</table>

*In a sleeping child, rates may be 10% lower.

**Slow (Bradycardic)**

Bradycardia is defined as heart rates slower than expected for the age of the patient and all heart rates below 60 beats per minute or a rapidly dropping heart rate despite adequate oxygenation and ventilation.

**Sinus Tachycardia**

In infants and children, sinus tachycardia is usually seen in response to a fever or dehydration. The complex structure is normal with discernible P-waves, QRS complexes, and T-waves. The rates are as follows:
- ♥ Infant and younger—from the upper limit of normal for the age group to 220 beats per minute
- ♥ Child—from the upper limit of normal for the age group up to 180 beats per minute

**Supraventricular Tachycardia**

Supraventricular tachycardia in children is most commonly caused by a *reentrant mechanism*. These are a group of arrhythmias characterized by impulses traveling through the heart, conducting a beat, and then reentering the conduction system at another point in the heart and conducting another beat. Because each impulse generates more than one contraction, the heart rate can become very fast. The P waves
may be buried or absent in these rhythms, and the QRS complexes are less than or equal to 0.08 of a second.

The rates in supraventricular tachycardia are as follows:
♥ Infant and younger—above 220 beats per minute
♥ Child—above 180 beats per minute

**Ventricular Tachycardia**

Ventricular tachycardia is an uncommon occurrence in children. When it is seen, the possibility of congenital heart disease or acute inflammatory injury to the heart must be considered. Drug overdose and metabolic imbalance should also be considered. In ventricular tachycardia the QRS complexes are wider than would be expected for normal and/or greater than 0.08 second. It is the wide QRS that defines this rhythm in the pediatric population, not necessarily the rate.

**Pediatric Resuscitations**

There are some differences worth noting in the working of a “code,” or cardiac arrest of the pediatric patient. The medication and electrical interventions, such as cardioversion and defibrillation, are weight based, so the use of a Broselow tape is commonly seen in both prehospital and emergency department resuscitations.
The Broselow tape is designed to estimate the weight of the patient and offer precalculated doses of medication, sizes of intubation tubes, blood pressure cuffs, intravenous needles, and other necessary resuscitative equipment. Each weight has a color. The color can be matched to resuscitation bags or drawers in a cart. These are stocked with enough supplies in the right size for one code. The tape also can be used as a guide to equipment when used with a pediatric code cart. In either case, a pediatric code card stocked specifically for pediatrics or neonates is essential in areas that specialize in this type of patient.