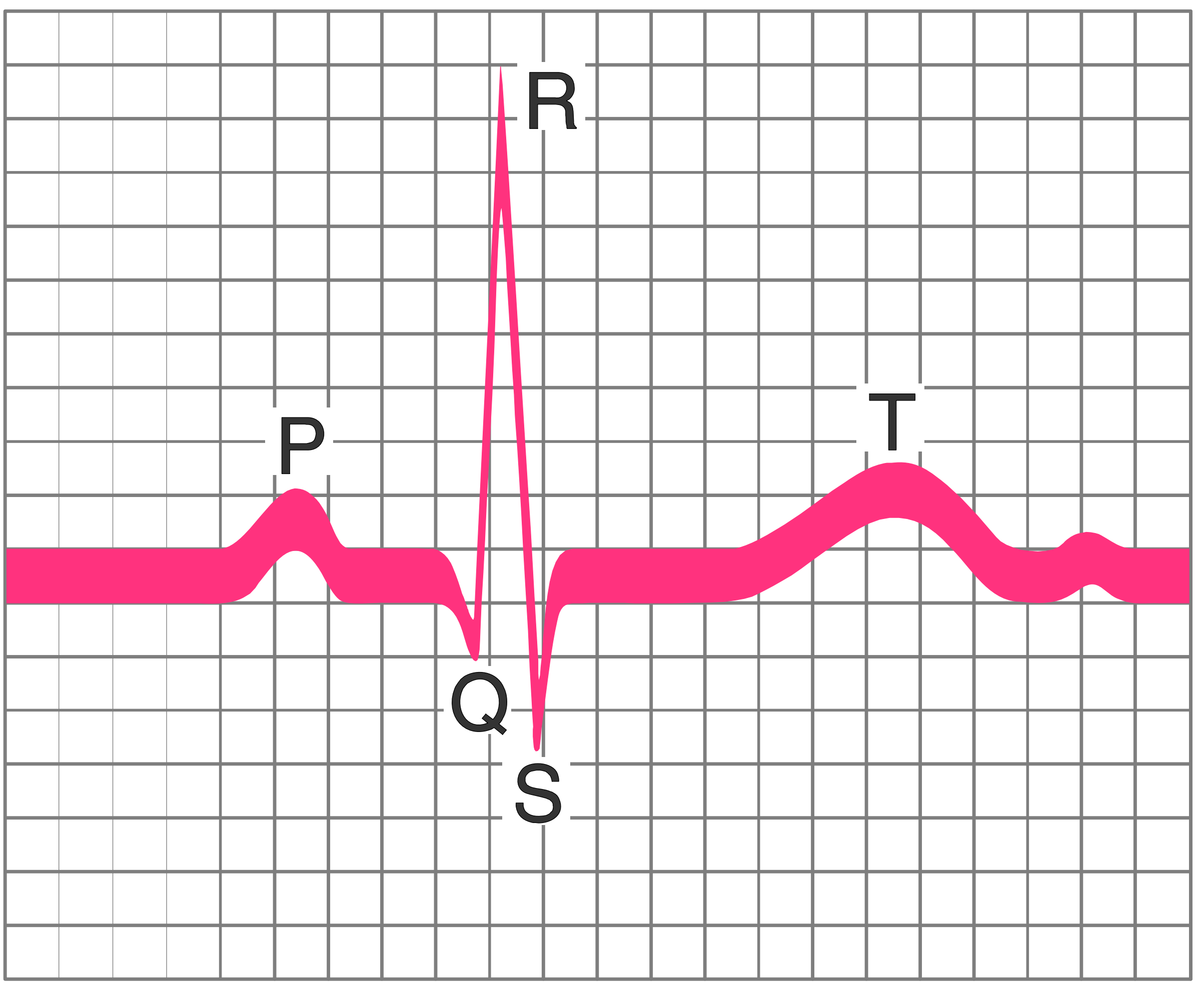
TCHP Education Consortium

ECG RHYTHM INTERPRETATION PRIMER



This educational activity expires December 31, 2017.

ECG INTERPRETATION PRIMER

Introduction/Purpose Statement

Interpretation of ECGs (Electrocardiograms; also known as EKGs) is one of the building blocks of nursing. Before the actual ECG interpretation can occur, a significant base of cardiac knowledge must be built. The purpose of this home study is to review the following topics: electrophysiology, anatomy and physiology, the normal conduction system, electrode placement, and ECG paper. This primer was developed to give you a starting point in learning how to interpret ECGs. *This primer is used as an introduction to the* ***"ECG Rhythm Interpretation" and "Pacemakers and ICDs"*** *classes.*

Target Audience

This home study was designed for the novice critical care or telemetry nurse; however, other health care professionals are invited to complete this packet.

Content Objectives

1. Describe the electrophysiology behind cardiac electrical action.
2. Identify the normal conduction of electrical current and the waveforms this current produces.
3. Describe the location and function of the following structures:
   - Sinoatrial (SA node)
   - Atrioventricular (AV) junction
   - Bundle of His
   - Bundle branches
   - Purkinje fibers
4. Identify preparation and placement of electrodes.

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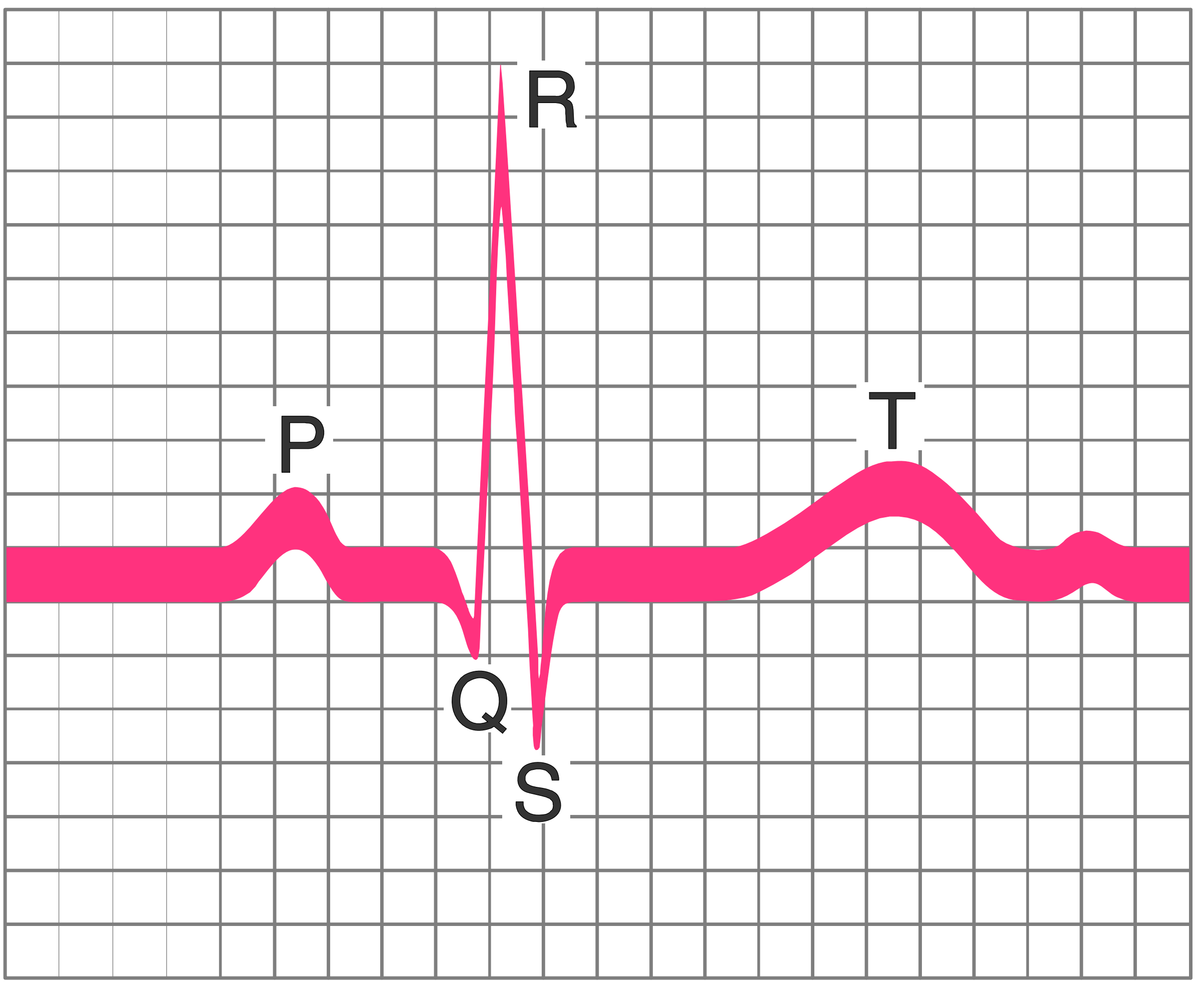
For completing this **Home Study and evaluation**, you are eligible to receive:	**1.0 MN Board of Nursing contact hours /0.83 ANCC contact hours** ***Criteria for successful completion:*** You must read the home study packet, complete the post-test and evaluation and submit them to TCHP for processing. The Twin Cities Health Professionals Education Consortium is an approved provider of continuing nursing education by the Wisconsin Nurses Association, an accredited approver by the American Nurses Credentialing Center's Commission on Accreditation.

Please see the last page of the packet before the post-test for information on submitting your post-test and evaluation for contact hours.

INTRODUCTION

As it beats, the heart generates small electrical currents. A recording of this electrical activity is called an "ECG" (electrocardiograph). The terms EKG and ECG mean the same thing. EKG comes from the German language while ECG comes from English. A standard ECG is obtained by placing electrodes on the patient's body in a specific pattern and monitoring the flow of the electrical activity. The test is entirely painless.

Each of the heart's beats can be divided into three main parts. The first part is the small P wave which represents the atrial contraction. The second part is the tall QRS spike which represents the ventricular contraction. The third part is the large T wave which represents the relaxation of the ventricles. By analyzing the exact pattern of the ECG, healthcare professionals can learn a great deal about how the heart is working.



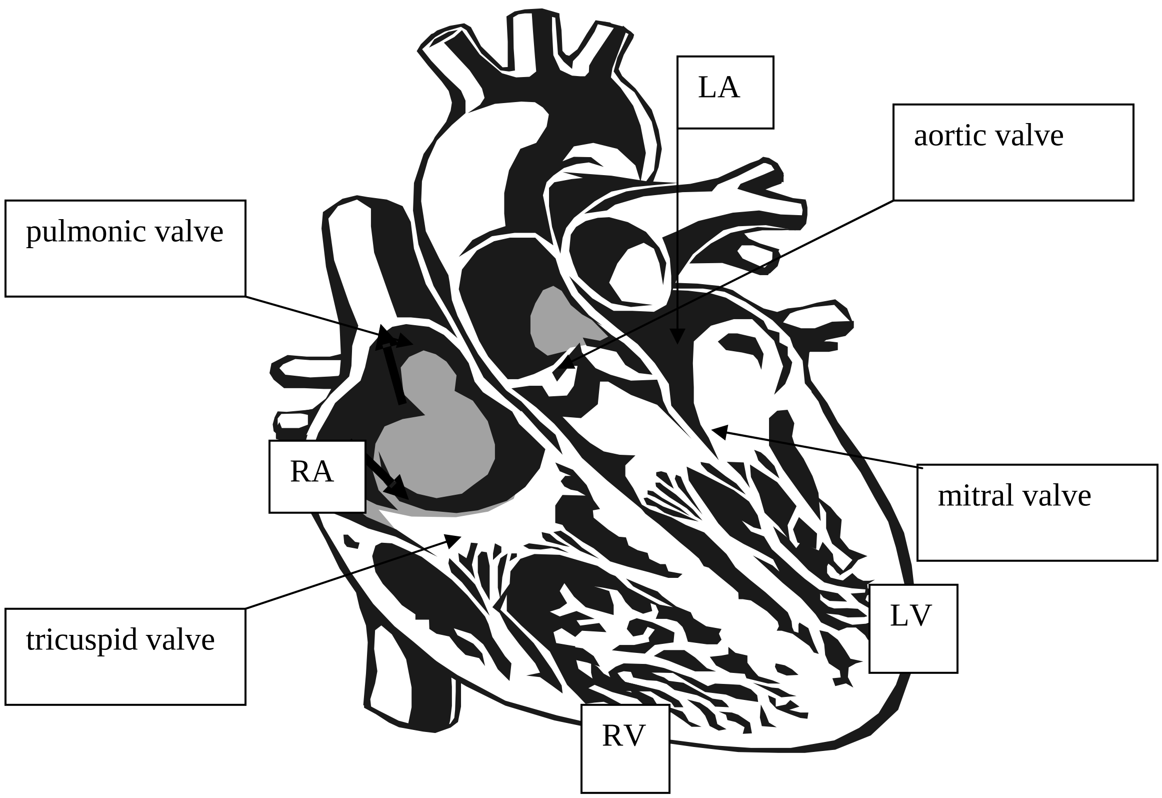
A Brief Anatomy and Physiology Lesson

Heart Valves

When blood flows through the heart, it follows a unidirectional pattern. There are four different valves within the myocardium and their functions are to assure blood flows from the right to left side of the myocardium and always in a “forward” direction.

The two valves found between the atria and ventricles are appropriately called atrioventricular (A-V) valves. The **tricuspid valve** separates the right atrium from the right ventricle. Similarly, the **mitral valve** separates the left atrium from the left ventricle. When these valves are intact, they prevent blood from backflow from the ventricle to the atrium during ventricular contraction.

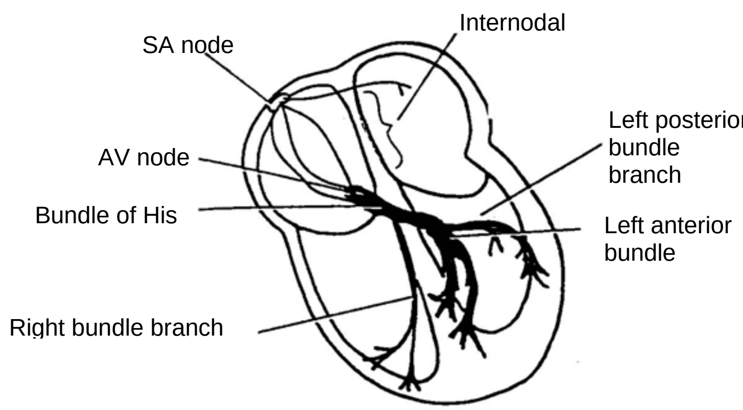
The two remaining valves are called semilunar valves (because they look like half moons). The valve located where the pulmonary artery meets the right ventricle is called the **pulmonic valve**. The **aortic valve** is located at the juncture of the left ventricle and aorta. Both semilunar valves prevent backflow of blood into the ventricles.



The Conduction System

An ECG is a road map of the electrical activity of cardiac cells during the contraction and relaxation of the heart. The sinoatrial (SA) node, atrioventricular (AV) node, Bundle of His, and down the branches to the Purkinje fibers are the normal pacing sites of the heart. In a healthy person, an ECG should demonstrate an organized, sequential electrical impulse from its beginning at the SA node to its conclusion at the Purkinje fibers. Cardiac electrical activity immediately precedes the contraction of cardiac muscle.

The **Sinoatrial node** (also called the **SA node** or **sinus node**) is a group of specialized cells located in the posterior wall of the right atrium. The SA node normally depolarizes or paces more rapidly than any other part of the conduction system. It sets off impulses that trigger atrial depolarization and contraction. Because the SA node discharges impulses quicker than any other part of the heart, it is commonly known as the natural **pacemaker** of the heart.

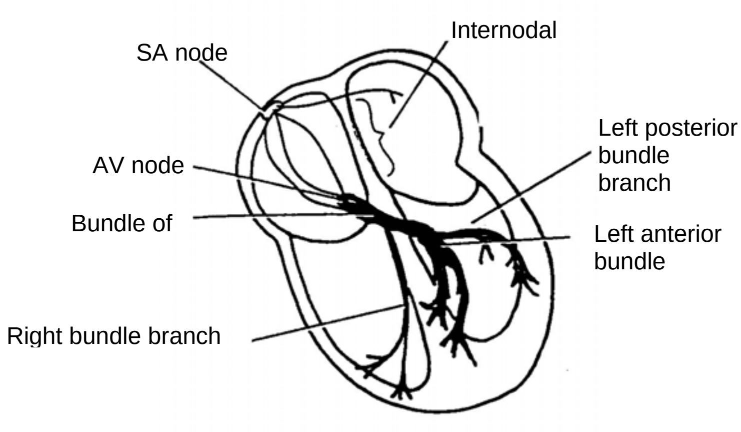


The SA node normally fires at a rate of 60-100 beats per minute.

After the SA node fires, a wave of cardiac cells begin to depolarize. Depolarization occurs throughout both the right and left atria (similar to the ripple effect when a rock is thrown into a pond). This impulse travels through the atria by way of inter-nodal pathways down to the next structure, which is called the AV node.

The impulse is delayed for 0.08 to 0.12 seconds in the **AV node**. This delay allows both atria to depolarize before the impulse continues through the remaining conduction system pathway. The AV node is a cluster of specialized cells located in the lower portion of the right atrium, above the base of the tricuspid valve.

The AV node has two functions. The first function as stated above, is to DELAY the electrical impulse in order to allow the atria time to contract and complete filling of the ventricles. The second function is to receive an electrical impulse and conduct it down to the ventricles via the **AV junction** and **Bundle of His.**



After passing through the AV node, the electrical impulse enters the **Bundle of His** (also referred to as the **common bundle**). The Bundle of His is located in the upper portion of the interventricular septum and connects the AV node with the two bundle branches. If the SA node should become diseased or fail to function properly, the Bundle of His has pacemaker cells, which are capable of discharging at **an intrinsic rate of 40-60 beats per minute**. This back-up pacemaker function can really come in handy!

The AV node blocks excessive atrial impulses from reaching the ventricles, thus preventing cardiac output from dropping to dangerous levels as a result of a fast ventricular rate. The AV node also has the ability to act as the pacemaker for the heart should the SA node fail or the impulses from the SA node become blocked.

The cardiac impulse then travels from the AV node to the Bundle of His, which divides into right and left bundle branches that travel to the ventricles. The bundle of His is located in the upper portion of the interventricular septum and connects the AV node with the two bundle branches. If the SA node should become diseased or fail to function properly, the Bundle of His has pacemaker cells, which are capable of discharging at **an intrinsic rate of 40-60 beats per minute**.

The cardiac impulse terminates with ventricular depolarization, which takes place in the Purkinje fibers located in the muscles of the ventricles. The Purkinje fibers penetrate about 1/4 to 1/3 of the way into the ventricular muscle mass and then become continuous with the cardiac muscle fibers. The electrical impulse spreads rapidly through the ventricular muscle, causing ventricular contraction, or systole.

These Purkinje fibers within the ventricles also have intrinsic pacemaker ability. This third and final pacemaker site of the myocardium can only **pace at a rate of 20-40 beats per minute**. You have probably noticed that the further you travel away from the SA node, the slower the backup pacemakers become.

ELECTROPHYSIOLOGY IN BRIEF

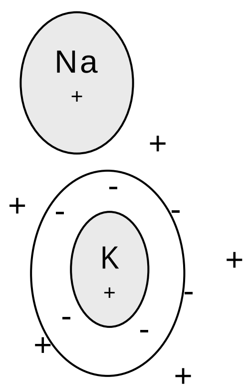
The heart is made up of two types of cells: those that generate or conduct electrical impulses, and those that contract and relax. We are focusing on the electrical cells in this learning activity.

Electrical cells have several unique characteristics:

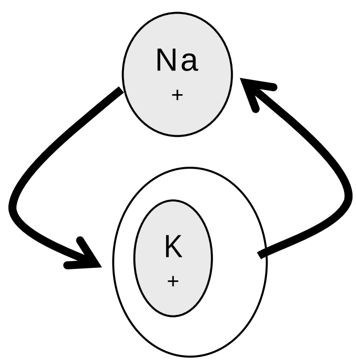
- *automaticity*: the cell can generate an electrical impulse without being stimulated
- *excitability*: the cell can change its internal electrical balance to reach threshold
- *conductivity*: the cell can move an electrical impulse to the next cell

The Sodium-Potassium Pump

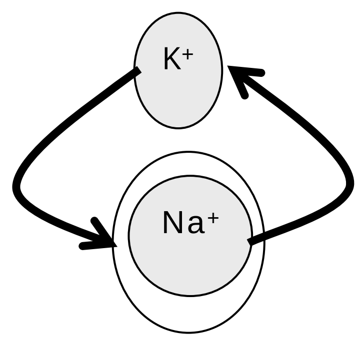
The mechanism that is involved with both automaticity and excitability is called the ***sodium-potassium pump***. Look at the illustration below to see how it works:



<u>Resting state=Polarized</u>
Potassium is inside the cell, and sodium is outside of the cell. There is nothing happening electrically.



<u>Depolarization</u>
Potassium leaves the cell and sodium enters the cell very quickly.



<u>Repolarization</u>
Potassium reenters the cell and sodium leaves the cell more slowly.

The Action Potential

Any stimulus that increases the permeability of the membrane to sodium causes an action potential. The action potential has four phases during resting, depolarization, and repolarization. Each phase represents a particular electrical event or combination of electrical events. The fast response is seen with cells that conduct the impulses; the slow response is seen in pacemaker cells:

Phase 0: depolarization

- sodium rushes into the cell

Phase 1: initial repolarization

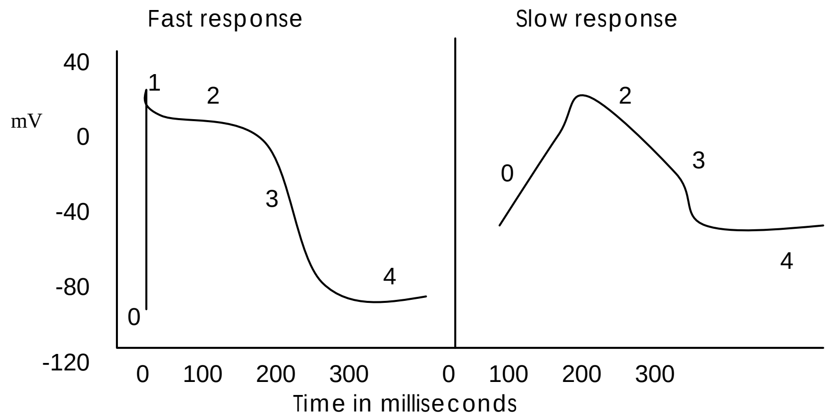
- chloride rushes in and stops sodium from entering the cell

Phase 2: plateau phase

- slow inward movement of calcium and slow exit of potassium

Phase 3: sudden repolarization

- potassium goes out more quickly and the slow calcium channel is inactivated



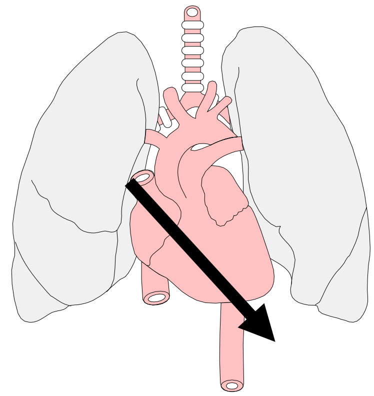
Phase 4

- potassium returns to the cell and sodium leaves the cell

All of the information on the ionic movement in the cells is fine for physiologists, but what does it mean for electrocardiographic monitoring? The answer: alterations in the movement of ions can affect what happens electrically in the patient's heart. Another answer: we give medications that affect how the ions move into and out of the cell, such as lidocaine (sodium), calcium channel blockers (calcium), and potassium.

The heart beat is usually divided into two main phases called "diastole" and "systole." During the first phase (diastole), the heart relaxes and fills with blood. During the second phase (systole), the heart contracts and pumps out the blood. The heart typically spends about 2/3 of its time in diastole and 1/3 of its time in systole. Keeping this activity well timed is the job of the heart's conduction system.

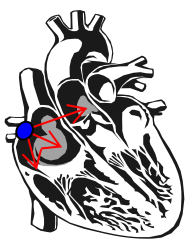
Flow of Electrical Current



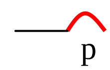
In a normal person, the heart is located in the middle of the chest to the left of the mediastinum. The sinoatrial (SA) node is located in the top of the right atrium, the atrioventricular (AV) node is located in the bottom of the atrium, and the bundle branches conduct through the septum and ventricles. Because of this normal flow, the direction of electrical flow (vector) is mainly downward, from right to left.

Impulse origin and atrial depolarization

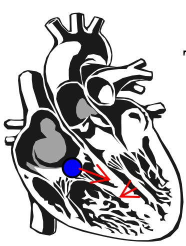
When the SA node, a pacemaker cell, fires off an impulse, the impulse travels down and toward the right and left atria. The direction -- or vector -- of this flow looks like this:



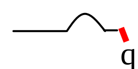
The electrical flow is translated to the ECG as the P wave. The waveform is relatively small – normally between 1.5 and 2.5 mm in width and less than 3 mm in height.



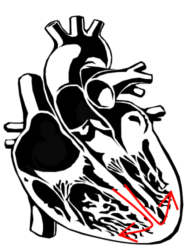
Septal depolarization



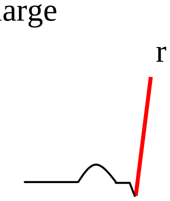
The electrical flow stops briefly at the AV node, and then travels quickly down the common bundle (Bundle of His) and through the right and left bundle branches to the interventricular septum. The depolarization of the septum causes a small negative deflection – a “q” wave in some leads; and a small positive deflection or “r” wave in others.



Apical and early ventricular depolarization

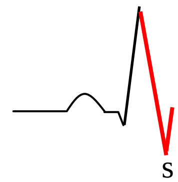


After depolarizing the septum, the impulse moves downward and to the left. This results in a large waveform – either an “R” wave or an “S” wave.

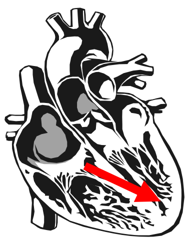


Late ventricular depolarization

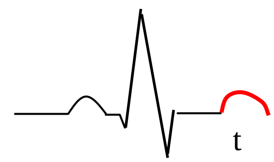
The final stage of depolarization takes place in the furthest stretches of the ventricle. The electrical stimulus moves upward, resulting in either a taller "R" wave or a smaller "S" wave.



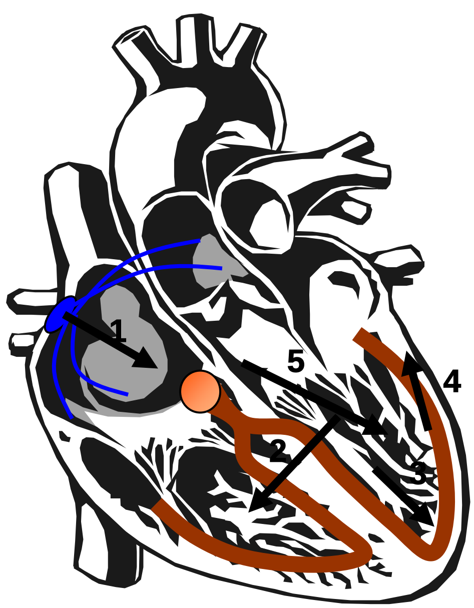
Ventricular repolarization



Finally, the electrical stimulus is completed, ending depolarization. The ions in the cells move back into their normal resting positions, from top to bottom, causing the T wave. The T wave should be the same vector as the mean QRS.



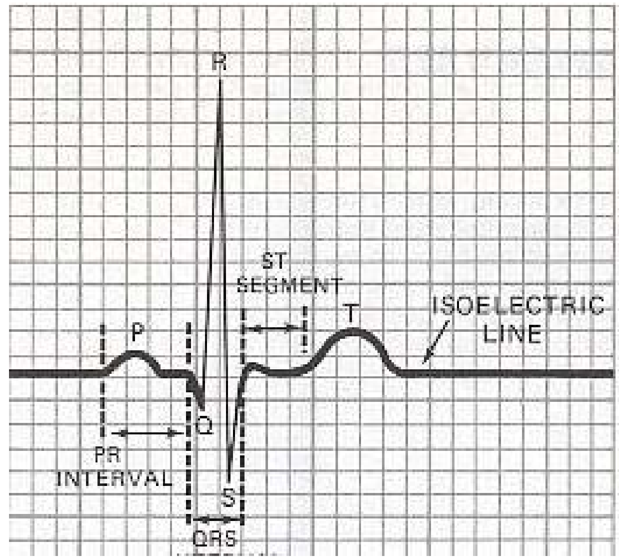
Putting the Whole Thing Together



1 = atrial depolarization = P wave
2 = SEPTAL DEPOLARIZATION = Q WAVE
3 = EARLY VENTRICULAR DEPOLARIZATION = TALL R OR S WAVE
4 = LATE VENTRICULAR DEPOLARIZATION = TALLER R WAVE OR S wave after R wave

THE ELECTROCARDIOGRAM WAVEFORMS

The Isoelectric Line



There is a place on the normal ECG rhythm that is electrically neutral - there is nothing electrically happening in the heart at that particular period. This is called the "isoelectric" line. This is located between the end of the T wave and the beginning of the next P wave.

P Wave

- Indicates atrial depolarization
- Shape - round and smooth
- The duration of the normal P wave is < 0.11 secs.
- The height of the normal P wave is < 3 mm

PR Interval

- The time from the beginning of atrial depolarization to the beginning of ventricular depolarization
- The normal duration of the PR is 0.12 – 0.20 seconds

QRS Complex

- Represents ventricular depolarization
- Normal width is < 0.12 seconds (rarely < 0.06 seconds)
- In the bipolar leads (I, II, III), the value of the positive and negative deflections of the QRS (add the small boxes up and down) should be more than 6 mm. Less than 6 mm indicates low voltage.

Where does the QRS complex start?
The QRS complex starts with either an upward or downward deflection after the PR interval. If the deflection goes down past the isoelectric line, it is called a "q" wave. If the deflection goes up past the isoelectric line, it is called an "r" wave.

The Q wave

- The "Q" wave is the first negative deflection before an R wave. If there is no negative deflection before the R wave, there is no "Q".

The R wave

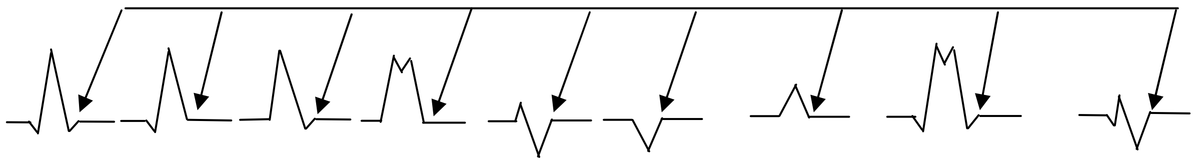
- The "R" wave is the first positive deflection after the PR interval. It is sometimes preceded by a "Q" wave.
- In some leads there may not be an "R" wave. Instead, there may be a "Q" wave and an "S" wave (a QS complex).

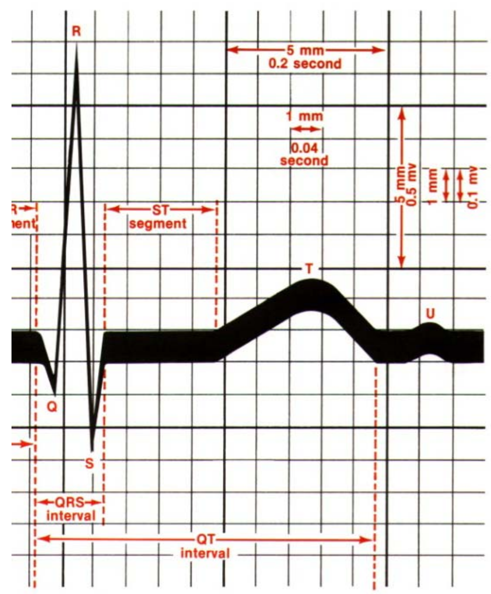
The S wave

- The "S" wave is the negative deflection that returns to the isoelectric line. It may be preceded by a "Q" wave, an "R" wave, or both.

Where does the QRS complex end?

The QRS ends at the "J" point: the point at which the S wave (or the R wave if there is no S wave) "turns a corner" —where the waveform moves in another direction. Below are the J-points as the R or S wave returns to the isoelectric line.



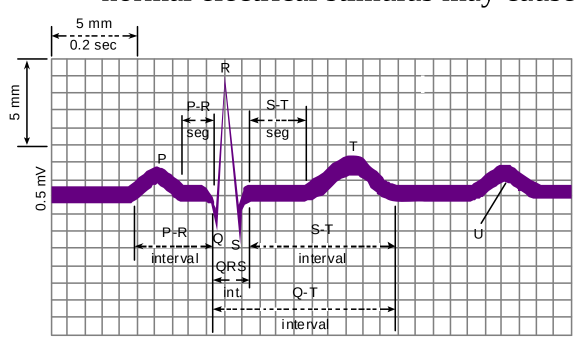


ST Segment

- Represents early ventricular repolarization
- The normal ST segment can be 1 mm (one small box) above or below the isoelectric line to be normal.
- The normal ST segment is > 0.08 secs in width.

T Wave

- Represents repolarization of ventricle
- Refractory periods
  - ❖ Absolute refractory period (ARP): The first half of the T wave where an electrical stimulus will not cause a depolarization (regardless of the stimulus strength)
  - ❖ Relative refractory period (RRP): The second half of the T wave, where a stronger than normal electrical stimulus may cause a depolarization



Electrode Placement and Lead Selection

Proper **electrode placement** is essential in order to acquire accurate ECG strips. Most ECG monitor manufacturers have a set of placement guidelines specific to their products

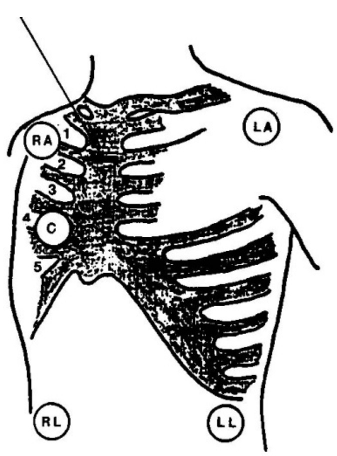
General guidelines

- Skin preparation:
    - Shave hair away from electrode placement site.
    - Rub site briskly with alcohol pad or wash well with soap and water and rinse.
    - Rub site with a 2x2 gauze.
    - Place electrode. Be sure that the electrode has adequate gel and is not dry.

- Lead placement:
    - Depolarization wave moving toward a positive lead will be upright.
    - Depolarization wave moving toward a negative lead will inverted.
    - Depolarization wave moving between negative and positive leads will have both upright and inverted components.

- More on Lead placement:
    - The ECG cables are often color-coded and labeled for ease of application and to reduce confusion about electrode to lead location.
    - The negative lead is usually white, the positive lead is red, and the ground lead is black, green, or brown.

Lead Placement: Option One (Standard 5-Lead Set-up)



- Use the following "memory trick" to help you recall where to place the leads: ***"white-to-right, "clouds over grass", "smoke over fire" and "chocolate is near and dear to my heart".***
- ***"White to right":*** The white lead is placed on the upper right side of the chest.
- ***"Clouds over grass":*** The white lead (clouds) is placed on the right side, while the green lead (grass) is located on the lower right chest.
- ***"Smoke over fire":*** The black lead (smoke) is on the left side of the chest, while the red lead (fire) is on the same side, but lower on the chest.
- ***"Chocolate is near and dear to my heart":*** The brown lead is located just to the right of the sternum at the fourth intercostal space.

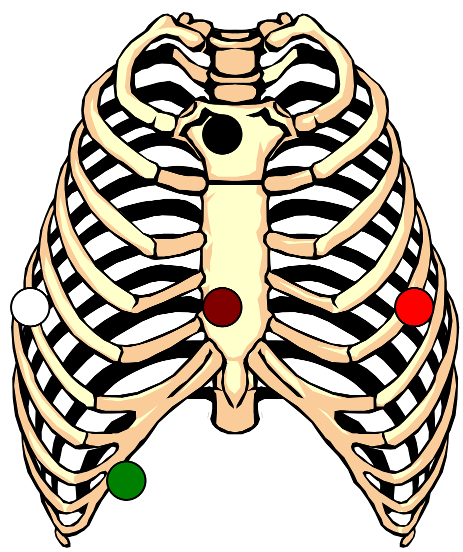
Lead Placement: Option Two

A new method for ECG electrode placement allows you to simulate a 12-Lead ECG. If your hospital utilizes this monitoring system, the leads are located differently than with a standard 5-lead set-up as discussed above.

Always follow the instruction manual that comes with the monitor when placing electrodes

.

- Black Lead: upper sternum
- Brown Lead: lower sternum
- White Lead: lower right chest
- Red Lead: lower left chest
- Green Lead: lower right chest, below the rib cage



Electrode trouble shooting and tips

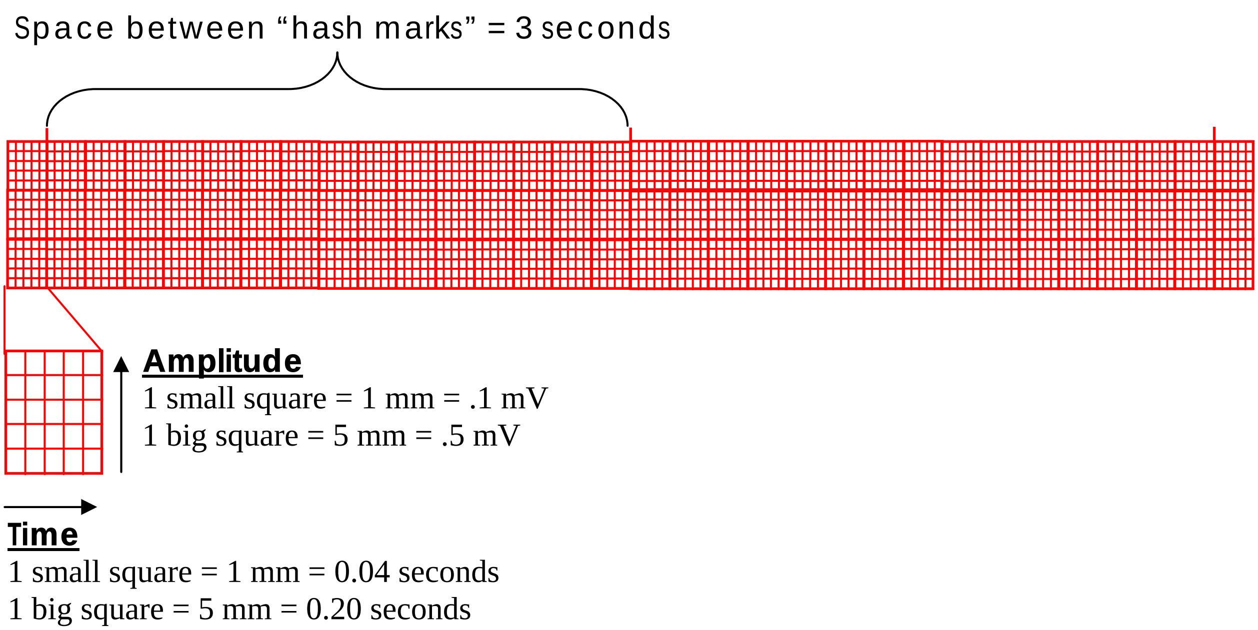
- Change the electrodes everyday and make sure the leads are tightly connected.
- Make sure all electrical patient care equipment is grounded.
- Be sure all the lead cables are intact.

- Be sure the patient's skin is clean and dry.
- Patient movement frequently causes interference. For example, the action of brushing teeth may cause interference that mimics V-tach.

THE ELECTROCARDIOGRAM

In order to interpret the ECG, a paper printout is obtained. All ECG paper is standardized, so that the width and height of the boxes can be easily measured in different patients and different facilities.

The grid of the paper indicates two things: time and amplitude. The "time" refers to the milliseconds it takes for a waveform to traverse the heart. The amplitude refers to the voltage of the electrical current.



Heart rate can be easily calculated from the ECG strip:

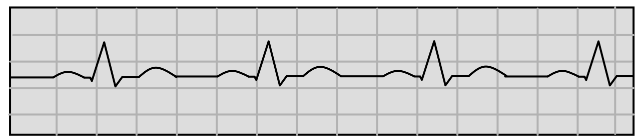
- When the rhythm is regular, the heart rate is 300 divided by the number of large squares between the QRS complexes.
  - For example, if there are 4 large squares between regular QRS complexes, the heart rate is 75 (300/4=75).
- The second method can be used with an irregular rhythm to estimate the rate. Count the number of R waves in a 6 second strip and multiply by 10.
  - For example, if there are 7 R waves in a 6 second strip, the heart rate is 70 (7x10=70).

STEPS IN INTERPRETING THE ECG

After you obtain an ECG on your patient, what do you do? There is a sequence of steps that is helpful to follow:

1. Assess the rate (atrial and ventricular) and regularity of the underlying rhythm. Assess the usual intervals and widths: PR interval, QRS width, QT interval.

2. Interpret the rhythm itself.

   Normal Findings:
   - The R-R intervals are regular.
   - The P-P intervals are regular.
   - There is one P for every QRS.

   Abnormal Findings:
   - The R-R intervals are irregular.
   - The P-P intervals are irregular.
   - There is more than one P for each QRS.
   - No P waves are visible.

3. Inspect the P wave:

   Normal Findings
   - P waves should be regular (march out the P-P intervals with your calipers).
   - P waves have a symmetrical shape, usually upright and rounded.
   - P waves should all look alike (uniform) and should point in the same direction.
   - There should be one P for every QRS (or a 1:1 relationship).

   Abnormal Findings
   - P wave is not followed by a QRS complex.
   - There are more P waves than QRS complexes.

4. Inspect the QRS complex:

   Normal Findings:
   - All the QRS complexes have uniformity throughout (the same size, shape and direction).
   - All QRS complexes are of equal duration or width.
   - The R to R interval between each QRS is regular.

   Abnormal Findings:
   - The QRS complexes vary in shape, width and direction.
   - The QRS complex is >.12 seconds wide.
   - The R to R interval between each QRS is irregular.

5. Inspect the ST segment -- it may be normal if it is one mm above or two mm below the isoelectric line.
   Normal Findings:
   - The ST segment should be electrically neutral (or near neutral) and should be sitting on the isoelectric baseline (no greater than 1 mm above or below the isoelectric line is normal).

   Abnormal Findings:
   - There is > 1mm ST segment elevation or depression from the isoelectric line.
   - The T wave is in the opposite direction than the R wave.

6. Inspect the T wave for:
   - direction of deflection
   - shape of the T wave
   - amplitude of the T wave

SUMMARY

This independent-learning activity was designed to give you some of the basic principles of ECG interpretation. Understanding what happens electrically in the heart, how the ECG monitors the electrical activity of the heart, and determining placement of electrodes will start you on the path to performing basic ECG rhythm interpretation.

Congratulations!

You have now completed the
ECG Rhythm Interpretation Primer!

DIRECTIONS FOR SUBMITTING YOUR POST TEST FOR CONTACT HOURS

To obtain a certificate of completion for this home study program, please complete the post-test and evaluation on the next few pages. If you are completing this home study as pre-reading for a TCHP class, please bring your post-test and evaluation to class with you for processing. The date on your certificate of completion will be the date that your home study is received. **Any materials received with a postmark after the expiration will be discarded.**

HealthEast, HCMC, & MVAMC Employees
If you are an employee of HealthEast, HCMC, or MVAMC, you may send the post-test and evaluation to TCHP for processing. Your post-test will be returned to you through your hospital. It cannot be mailed to your home.

Paid Participants
If you are not an employee of one of the TCHP hospitals, please send the post-test and evaluation to TCHP with a check for $6.00. Please make check payable to **TCHP Education Consortium** and mail to:

TCHP Education Consortium
Capitol Office Building,
525 Park Street, Suite 120
St. Paul, MN 55103

Your post-test will be returned to you with the certificate of completion.

ECG Rhythm Interpretation Primer
Post-Test

Please print all information clearly and sign the verification statement:

Name______________________________
(please print legal name above)

Birth date **(required)** Format: 01/03/1999								
	M	M	D	D	Y	Y	Y	Y

For HealthEast, HCMC, or MVAMC, employees only:

Hospital ______________Unit______________

Personal verification of successful completion of this educational activity (required):
I verify that I have read this home study and have completed the post-test and evaluation.

____
Signature

1) Which of the following is not a characteristic of cardiac electrical cells?
   a) automaticity
   b) excitability
   c) conductivity
   d) contractility

2) The isoelectric line is located between the:
   a) QRS and T wave
   b) P wave and QRS
   c) T and P waves
   d) Q and T waves

3) The PR interval:
   a) Starts at the beginning of atrial depolarization
   b) Ends at the beginning of ventricular depolarization
   c) The normal duration is 0.12 – 0.20 seconds
   d) all of the above

4) Which of the following is commonly known as the "natural pacemaker of the heart"?
   a) SA Node
   b) AV Node
   c) Bundle of His
   d) Purkinje Fibers

5) A depolarization wave moving toward a positive lead will be:
   a) inverted
   b) upright
   c) both upright and inverted components
   d) none of the above

6) If there are 5 R waves in a 6 second strip, the heart rate is about:
   a) 100/minute
   b) 50 /minute
   c) It depends on the atrial rate
   d) none of the above

7) The QRS complex:

a) starts with either an upward or downward deflection after the PR interval
b) is usually more than 6 mm in height
c) is usually less than 0.12 seconds in duration
d) all of the above

Expiration date: The last day that post tests will be accepted for this edition is December 31, 2017—your envelope must be postmarked on or before that day.

Match the following waveforms with the part of the cardiac cycle that they represent:

a) P Wave

b) PR Interval

c) QRS Complex

d) ST Segment

e) T Wave

8) Ventricular depolarization_____________

9) Early ventricular repolarization_____________

10) Ventricular repolarization__________

11) Atrial depolarization______________

12) The time from the beginning of atrial depolarization to the beginning of ventricular depolarization____________

Evaluation: ECG Rhythm Interpretation Primer

Please complete the evaluation form below by placing an "X" in the box that best fits your evaluation of this educational activity. Completion of this form is required to successfully complete the activity and be awarded contact hours.

At the end of this home study program, I am able to:	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1. Describe the electrophysiology behind cardiac electrical action.					
2. Identify the normal conduction of electrical current and the waveforms this current produces.					
3. Describe the location and function of the following structures: Sinoatrial (SA node), Atrioventricular (AV) junction, Bundle of His, Bundle branches, Purkinje fibers					
4. Identify preparation and placement of electrodes					
5. Describe the electrophysiology behind cardiac electrical action.					
6. The teaching / learning resources were effective. *If not, please comment:*					

The following were disclosed in writing prior to, or at the start of, this educational activity (please refer to the first 2 pages of the booklet).		
	Yes	**No**
7. Notice of requirements for successful completion, including purpose and objectives		
8. Conflict of interest		
9. Disclosure of relevant financial relationships and mechanism to identify and resolve conflicts of interest		
10. Sponsorship or commercial support		
11. Non-endorsement of products		
12. Off-label use		
13. Expiration Date for Awarding Contact Hours		
14. Did you, as a participant, notice any bias in this educational activity that was not previously disclosed? *If yes, please describe the nature of the bias:*		

15. How long did it take you to read this home study and complete the post test and evaluation: ______hours and ______minutes.

16. Did you feel that the number of contact hours offered for this educational activity was appropriate for the amount of time you spent on it?
____Yes
____No, more contact hours should have been offered
____No, fewer contact hours should have been offered.

Expiration date: December 31, 2017