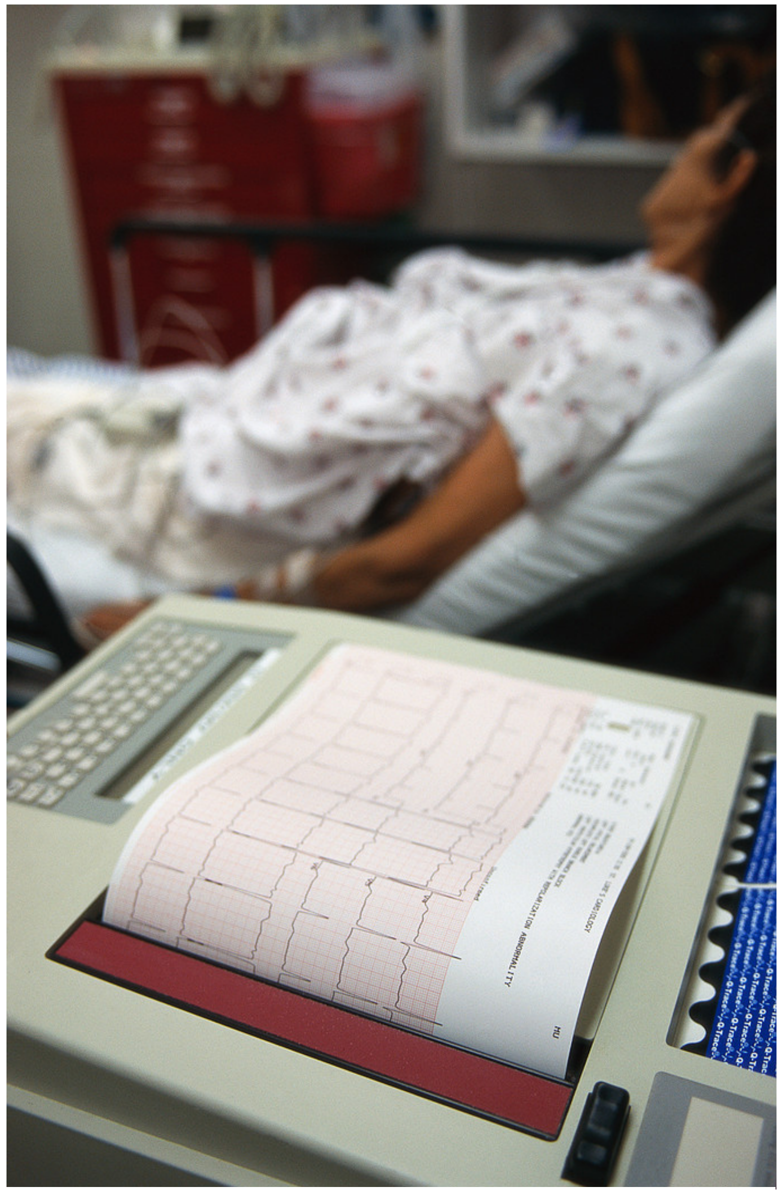
ADVANCED 12-LEAD EKG INTER-PRETATION PRIMER



ADVANCED 12-LEAD EKG INTERPRETATION PRIMER

Introduction/Purpose Statement

Recognizing changes on the 12-lead EKG is an important part of monitoring in the critical care and telemetry environments. Learning how to monitor the 12-lead EKG, however, can be an intimidating prospect. The purpose of this primer is to give you a starting point in learning how to interpret 12-lead EKGs. *This primer can be used as either a stand-alone educational activity or as an introduction to the* ***"Advanced 12-Lead EKG Interpretation"*** *class.*

Target Audience

This home study was designed for nurses with at least one year of experience in interpreting ECGs; however, other health care professionals are invited to complete this packet.

Content Objectives: After Completing This Primer, You Will Be Able To:

1. Describe the electrophysiology behind cardiac electrical action.
2. Identify the normal conduction of electrical current and the waveforms this current produces.
3. Explain when a waveform is upright or negative.
4. Describe the normal waveforms in each of the 12 leads.
5. Identify which leads look at which parts of the heart wall.
6. Identify the axis of the QRS complex in two different ways.

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In order to successfully complete this activity you must read the home study, complete the post-test and evaluation, and submit them for processing.

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Expiration Date for this Activity:
As required by ANCC, this continuing education activity must carry an 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.

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Contact Hour Information

For completing this **Home Study and evaluation**, you are eligible to receive:	**2.5 MN Board of Nursing contact hours / 2.08 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

The 12-lead electrocardiogram is a valuable tool in assessing the heart's electrical activity. It provides information related to dysrhythmias, heart chamber size and position, and cardiac ischemia or infarction.

The first sensitive machine for recording the heart's electrical activity was developed in 1903 by Professor Einthoven from the Netherlands. His machine record electrical activity between three pairs of electrodes, which he named "lead I," "lead II," and "lead III." Professor Einthoven's invention allows us today to monitor the electrical activity of the heart in 12 leads.

Before reviewing what the twelve leads monitor, we'd like to bring you through a tour of the anatomy and physiology of the heart.

A BRIEF HISTORY OF ELECTROPHYSIOLOGY

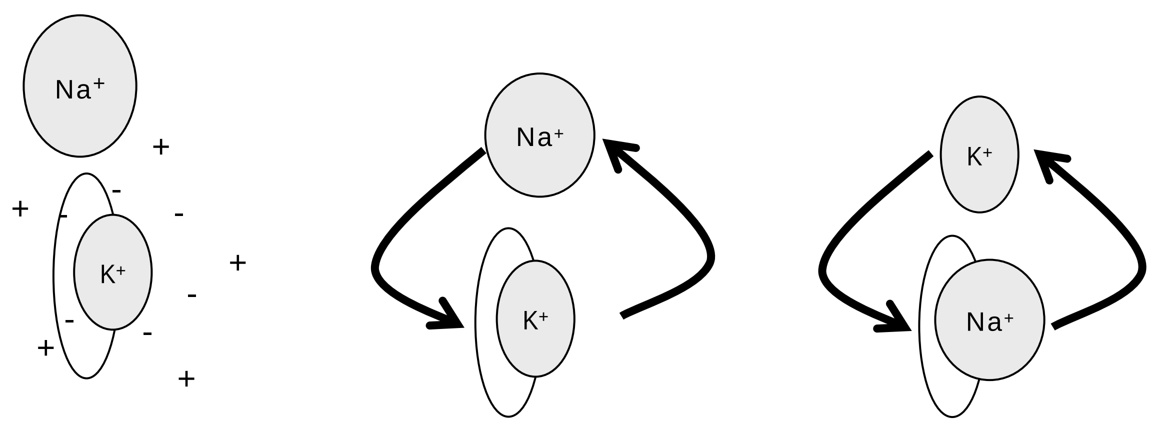
The heart is made up of two types of cells: those that generate or conduct electrical impulses, and those that contract and relax. We are focusing on the electrical cells in this learning activity.

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:



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

Depolarization
Potassium leaves the cell and sodium enters the cell very quickly.

Repolarization
Potassium reenters the cell and sodium leaves the cell more slowly.

The Action Potential

The action potential has four phases of resting, depolarization, and repolarization. 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 an the fast inward sodium current is inactivated

Phase 2: plateau phase

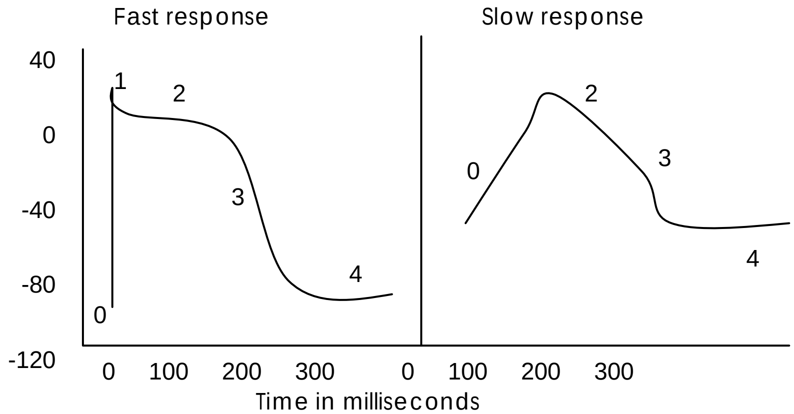
- slow inward movement of calcium and slow exit of potassium

Phase 3: sudden repolarization

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

Phase 4

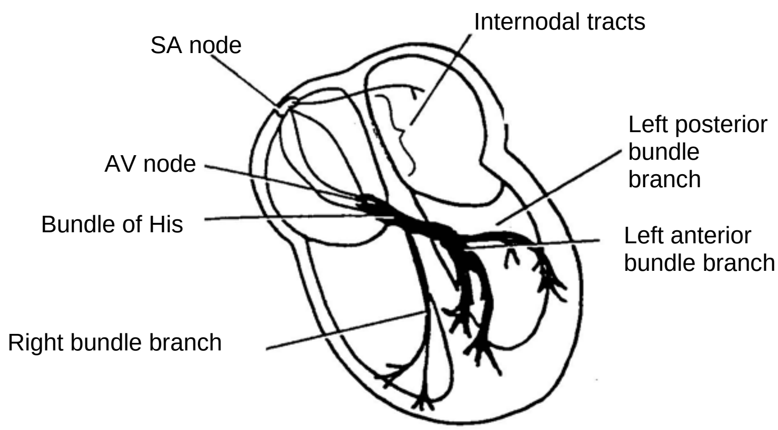
- potassium and sodium reverse concentrations to polarized state



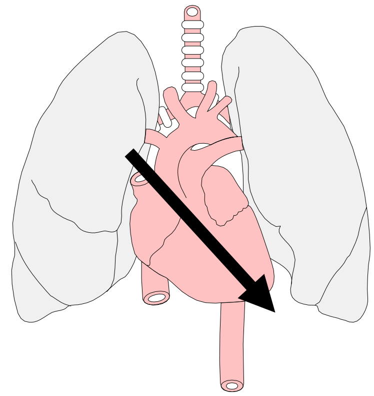
All of the information on the ionic movement in the cells is fine for physiologists, but what does it mean for electrocardiographic monitoring? The answer: alterations in the movement of ions can affect what happens electrically in the patients heart. Another answer: we give medications that affect how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

The Conduction System

The end result of ionic movement and action potential produces an electrical stimulus that is propagated from one cell to the other. The conduction system hooks all of the electrical cells together to conduct an impulse along an organized pathway.



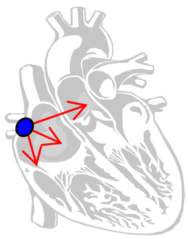
Flow of Electrical Current



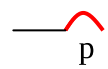
In the normal person, the heart is located in the middle of the chest to the left of the mediastinum. The sinoatrial (SA) node is located in the top of the right atrium, the atrioventricular (AV) node is located in the bottom of the atrium, and the bundle branches conduct through the septum and ventricles.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

Impulse origin and atrial depolarization

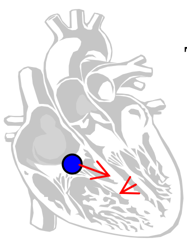
When the SA node, a pacemaker cell, fires off an impulse, the impulse travels down and toward the right and left atria. The direction -- or vector -- of this flow looks like this:



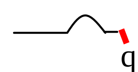
The electrical flow is translated to the ECG as the P wave. The waveform is relatively small – normally between 1.5 and 2.5 mm in width and less than 3 mm in height.



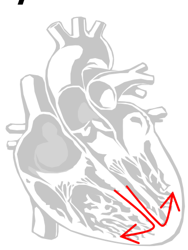
Septal depolarization



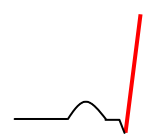
The electrical flow stops briefly at the AV node, then travels quickly down the common bundle (Bundle of His) and through the right and left bundle branches to the interventricular septum. The depolarization of the septum causes a small deflection – a "q" wave in some leads; and a small "r" wave in others.



Apical and early ventricular depolarization

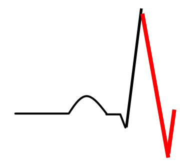


After depolarizing the septum, the impulse moves downward and to the left. This results in a large waveform – either an "R" wave or an "S" wave.

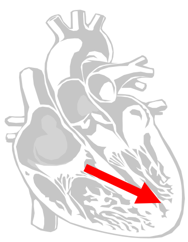


Late ventricular depolarization

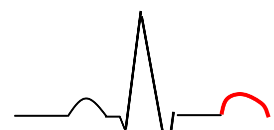
The final stage of depolarization takes place in the furthest stretches of the ventricle. The electrical stimulus moves upward, resulting in either a taller "R" wave or a smaller "S" wave.



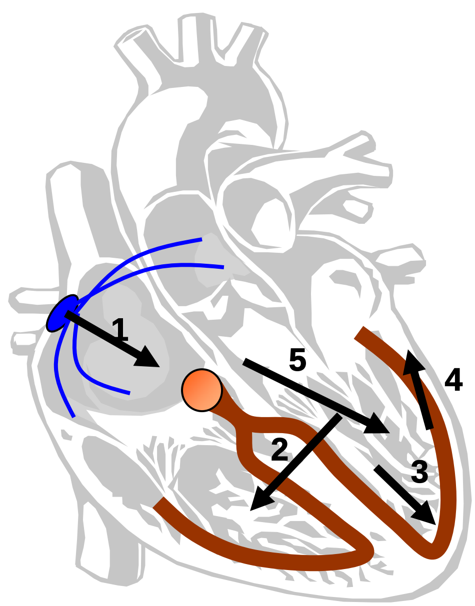
Ventricular repolarization



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

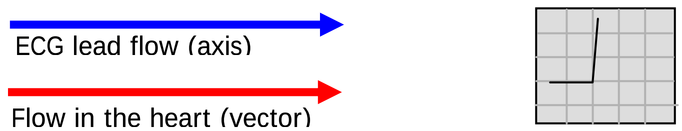


1 = atrial depolarization = P wave
2 = septal depolarization = Q wave
3 = early ventricular depolarization = tall R or S wave
4 = late ventricular depolarization = taller R wave or S wave after R wave
5 = ventricular repolarization = T wave

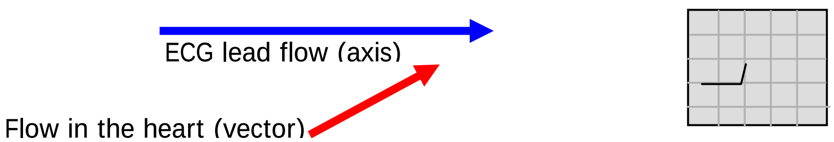
What the 12 Leads See

There is one positive and one negative electrode on each lead. ***Current flows from the negative to the positive electrode***. The direction of current flow from one electrode to the other (axis) is compared to the direction of current flow in the heart (vector).

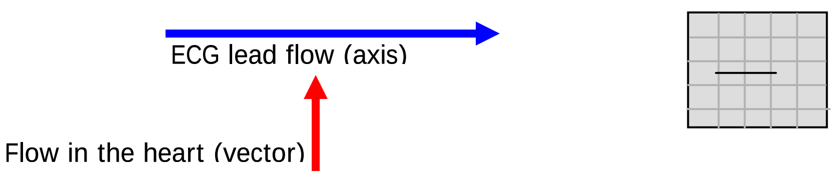
If both currents are flowing in the same direction, the waveforms are upright and tall.



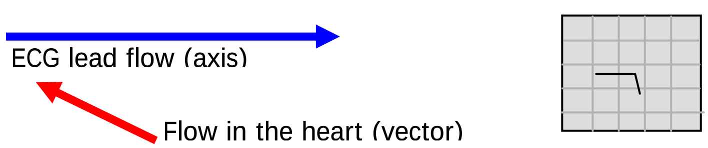
If the current in the heart is flowing obliquely to the axis of the lead, the waveforms are upright, but smaller.



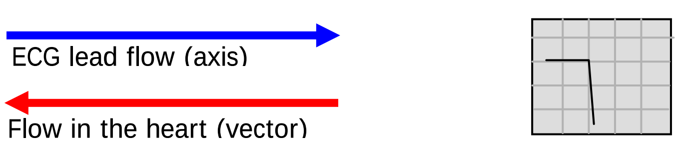
If the currents are perpendicular to each other, the waveform is flat.



If the current of the heart is flowing obliquely away from the axis of the lead, the waveforms are deflected weakly downward.

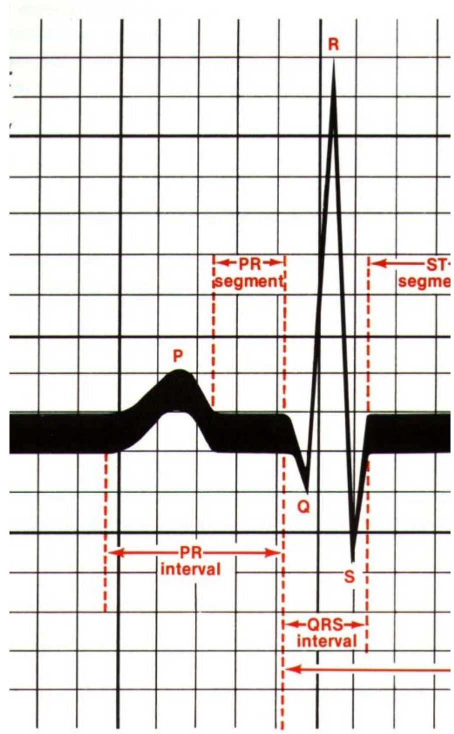


If the current of the heart is flowing directly away from the axis of the lead, the waveforms are deflected strongly downward.



ECG 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.
- In the precordial leads (V1-V6), the QRS should be less than 30 mm in height.

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".
- A q wave is normal in I, aVL, V_5 and V_6 if it is < 0.04 secs in width and < 25% the height of the R wave.

The R wave

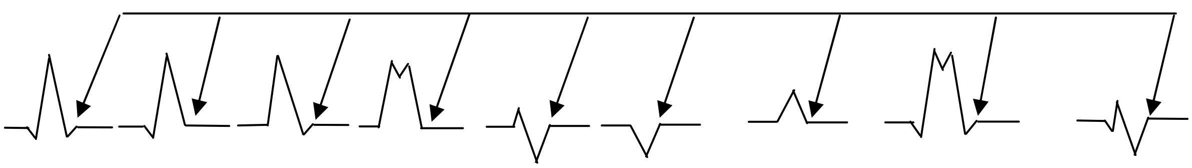
- The "R" wave is the first positive deflection after the PR interval. It is sometimes preceded by a "Q" wave.
- In some leads (aVR and V1), there may not be an "R" wave. Instead, there may be a "Q" wave and an "S" wave (a QS complex).

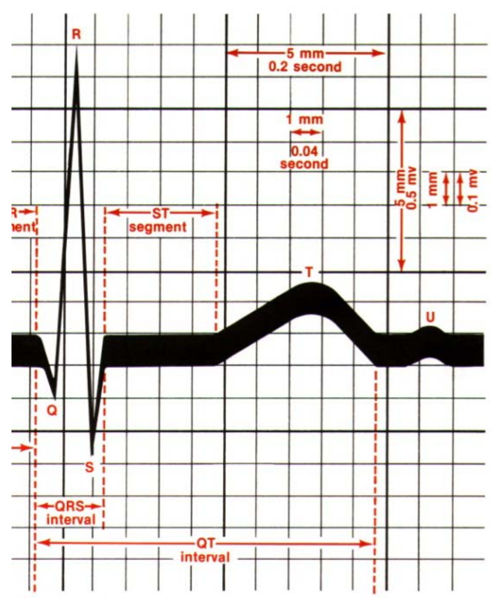
The S wave

- 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.
- Early repolarization can be seen in some patients, where the ST segment appears to be elevated in leads V_2 and V_3. This is in fact a T wave that occurs early, and is not significant.

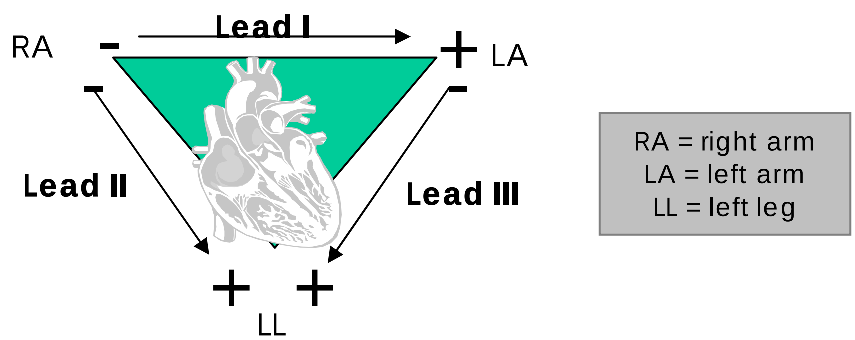
T Wave

- Represents repolarization of ventricle

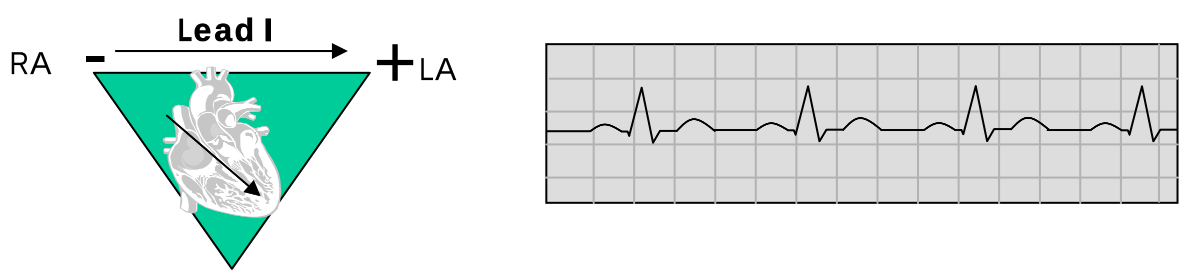
- The T wave should be < 5 mm in leads I, II, and III and < 10 mm in V_1-V_6
- Refractory periods
  - ❖ Absolute refractory period (ERP): The first half of the T wave where an electrical stimulus will not cause a depolarization (regardless of the stimulus strength)
  - ❖ Relative refractory period (RRP): The second half of the T wave, where a stronger than normal electrical stimulus may cause a depolarization

The Bipolar (Frontal) Leads

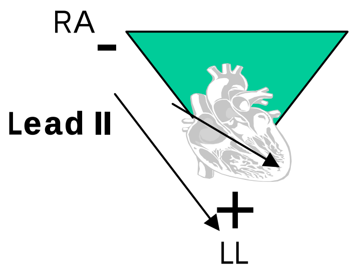
The first three leads are those that were discovered by Professor Einthoven. His theoretical model is called "Einthoven's Triangle," and looks like the diagram below:

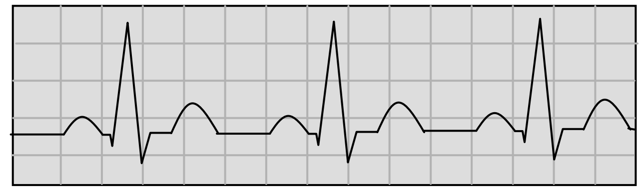


Lead I has the negative electrode on the right arm and positive electrode on the left arm. If you will look back to the "Putting it All Together" picture on the previous page, you will note that the current flows from right to left in Lead I. This flow matches the flow of the P, R, and T wave currents, so those waveforms should be upright. There is a "q," representing septal flow, and an "s," representing late ventricular depolarization.

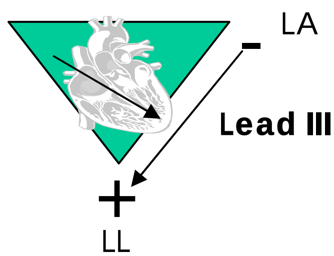


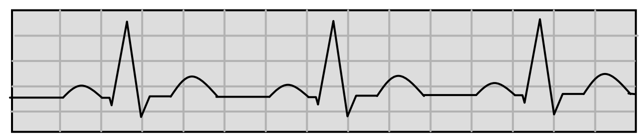
Lead II has the negative electrode on the right arm and positive electrode on the left leg. The flow is in almost exactly the same current flow as the heart. The P, R, and T waves are strongly positive, with slightly deeper Q and S waves than in Lead I.





Lead III has the negative electrode on the left arm and positive electrode on the left leg. The waveforms should look much the same as in Lead II, but the positive waveforms will be "shorter" than in Lead II. In fact, the R wave may be very flat.

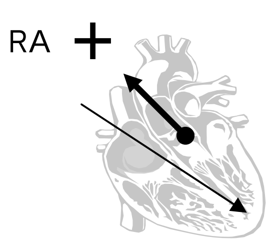


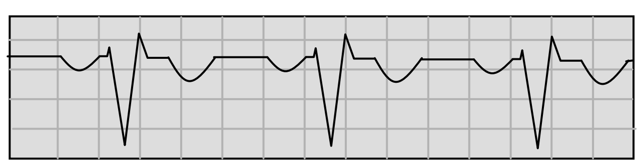


The Augmented Unipolar Leads

The following three leads have only one pole. The thought is that the negative pole is in the center of the heart and the positive pole is a lead on either the right arm, the left arm, or the left leg.

Lead aVR has the positive electrode on the right arm. The current flow is directly opposite of the hearts' flow, so the P wave and T wave are inverted, and there is little or no R wave. Instead, there is often a deeper S wave. Lead aVR looks at the right atrium and the upper portion of the right ventricle.





Lead aVL has the positive electrode on the left arm. The current flow is perpendicular to the mean vector of current flow. There is often a deep Q and S wave, with flat, inverted, or upright P and T waves. Lead aVL looks at the left atrium and the upper portion of the left ventricle.

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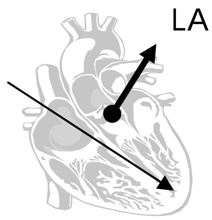
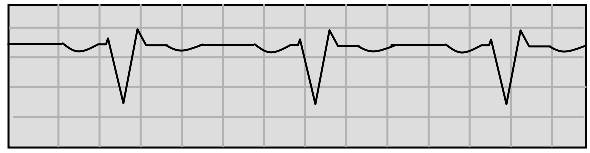
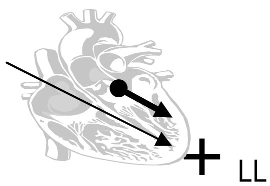
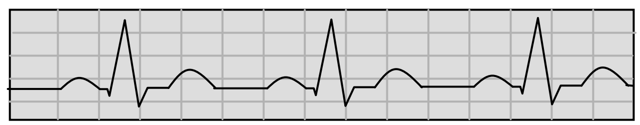




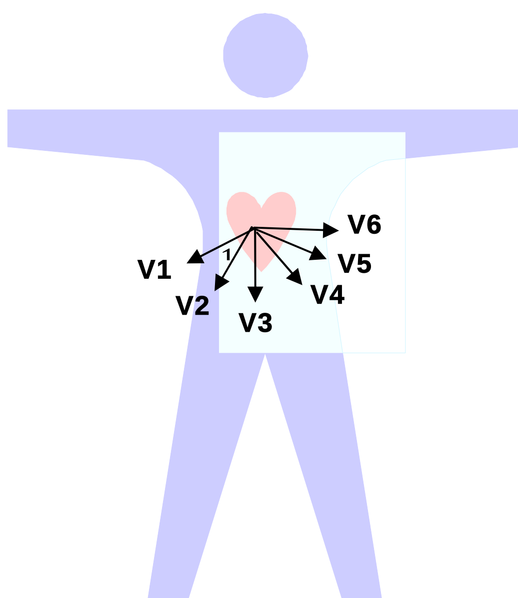
Lead aVF has the positive electrode on the left leg. The current flow is the same as the mean vector of current flow. There is normally an upright P, R, and T wave, with small q and s waves. Lead aVF looks at the lower portion of the left ventricle.



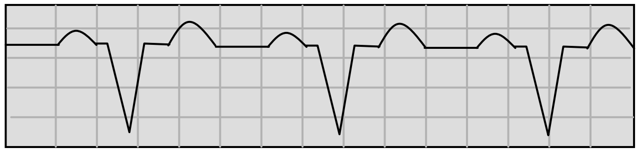


The Precordial Leads

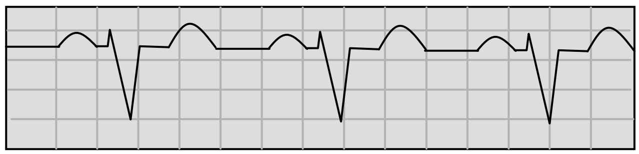
The precordial leads also assume a negative pole in the center of the heart, just like the augmented leads. The precordial leads measure current flow that indicates what is happening in the right and left ventricles.



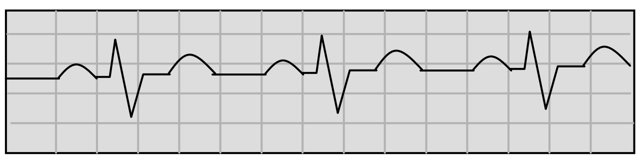
Lead V1 has the positive electrode at the fourth intercostal space at the right sternal border. It looks at the right ventricle and septum. The “P” and “T" waves may be upright, inverted, or diphasic.



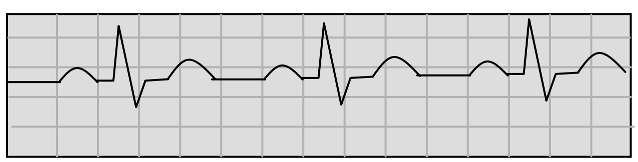
Lead V2 has the positive electrode at the fourth intercostal space at the left sternal border. It looks at the right ventricle and septum. The P and T waves are usually upright, but may be inverted, or diphasic.



Lead V3 has the positive electrode between the fourth and fifth intercostal space. This lead looks at the anterior wall of the left ventricle. The P and T waves are upright, and the R wave height is approximately the same as the S wave depth.

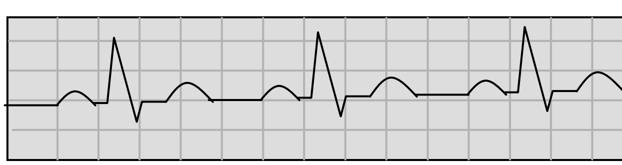


Lead V4 has the positive electrode at the fifth intercostal space and the midclavicular line. This lead also looks at the anterior wall of the left ventricle. The P and T waves are upright, and the R wave height is either the same as or taller than the S wave depth.

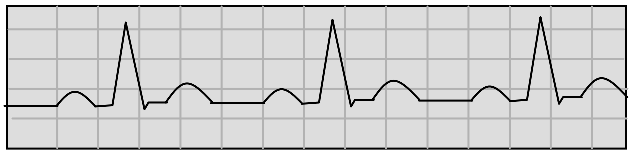


Either Lead V3 or V4 are known as the "transition," where the QRS complex is equally above and below the baseline.

Lead V5 has the positive electrode at the fifth intercostal space and the left axillary line. This lead looks at the anterior and lateral walls of the left ventricle. The P and T waves are upright, and the R wave height is taller than the S wave depth.



Lead V6 has the positive electrode at the fifth intercostal space and the left midaxillary line. This lead looks at the lateral wall of the left ventricle. The P and T waves are upright, and the R wave is dominant with only a small S wave (if any at all).



Normal ECG Configurations Summary Sheet

- P wave < 3 mm in height
- Q wave < 0.04 seconds in width, and < 25% the height of the R wave
- QRS > 6 mm in I, II, III
- QRS < 30 mm in V1-V6

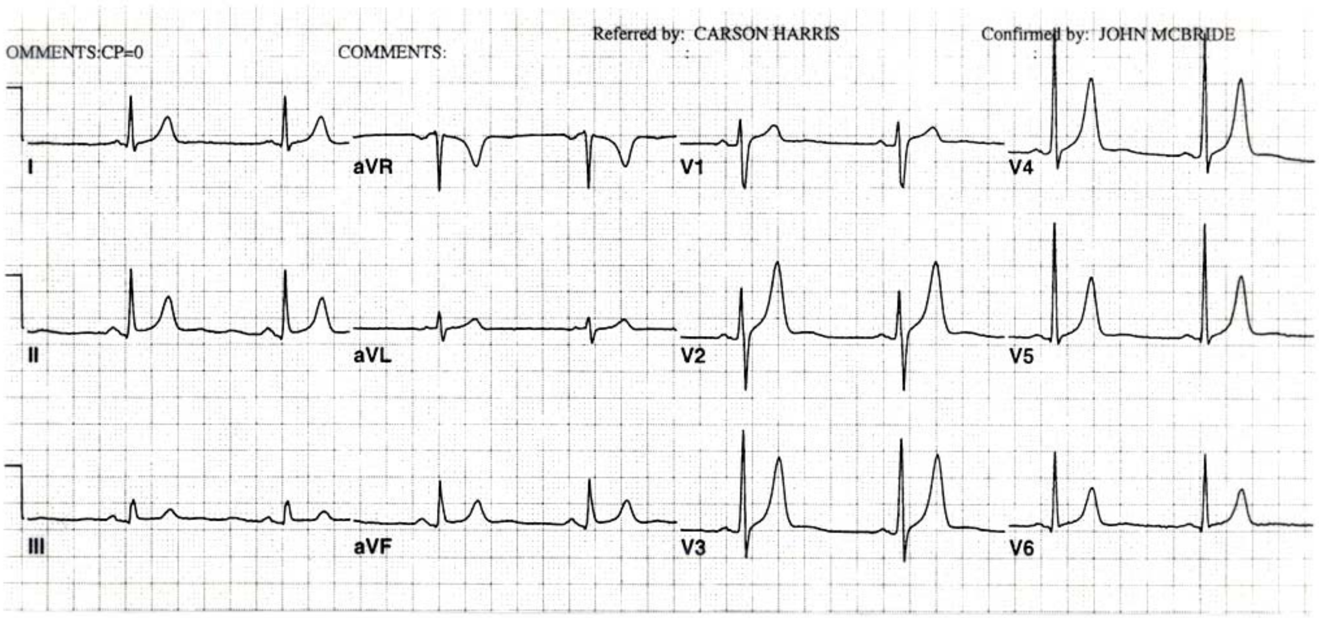
Lead	P wave	Q wave	R wave	S wave	T wave	ST segment
I	upright	small	largest wave	small or none	upright, < 5 mm	+1 to -0.5 mm
II	upright	none	large	small or none	upright, < 5 mm	+1 to -0.5 mm
III	variable	small or none	none to large	none to large	variable	+1 to -0.5 mm
aVR	inverted	small, none, or large (QS)	small or none	large	inverted	+1 to -0.5 mm
aVL	variable	small, none, or large	small, none, or large	none to large	variable	+1 to -0.5 mm
aVF	upright	small or none	small or none	small, none, or large	variable	+1 to -0.5 mm
V1	variable	QS complex	small or none	large (QS)	variable	0 to +2 mm
V2	upright	none	larger than V1	large	upright, < 10 mm	0 to +2 mm
V3	upright	none	≤, ≥, or = to S wave	≤, ≥, or = to R wave	upright, < 10 mm	0 to +2 mm
V4	upright	none	taller than V3	smaller than V3	upright, < 10 mm	+1 to -0.5 mm
V5	upright	small	larger than V4	smaller than V4	upright, < 10 mm	+1 to -0.5 mm
V6	upright	small	≤ V5	≤ V5	upright, 10 mm	+1 to -0.5 mm

Adapted from Menzel, L.K. (1989). The electrocardiogram during myocardial infarction, AACN Clinical Issues in Critical Care, 3(1), 194-195 and Conover, M.B. (1996). Understanding Electrocardiography, Mosby.

PRACTICE

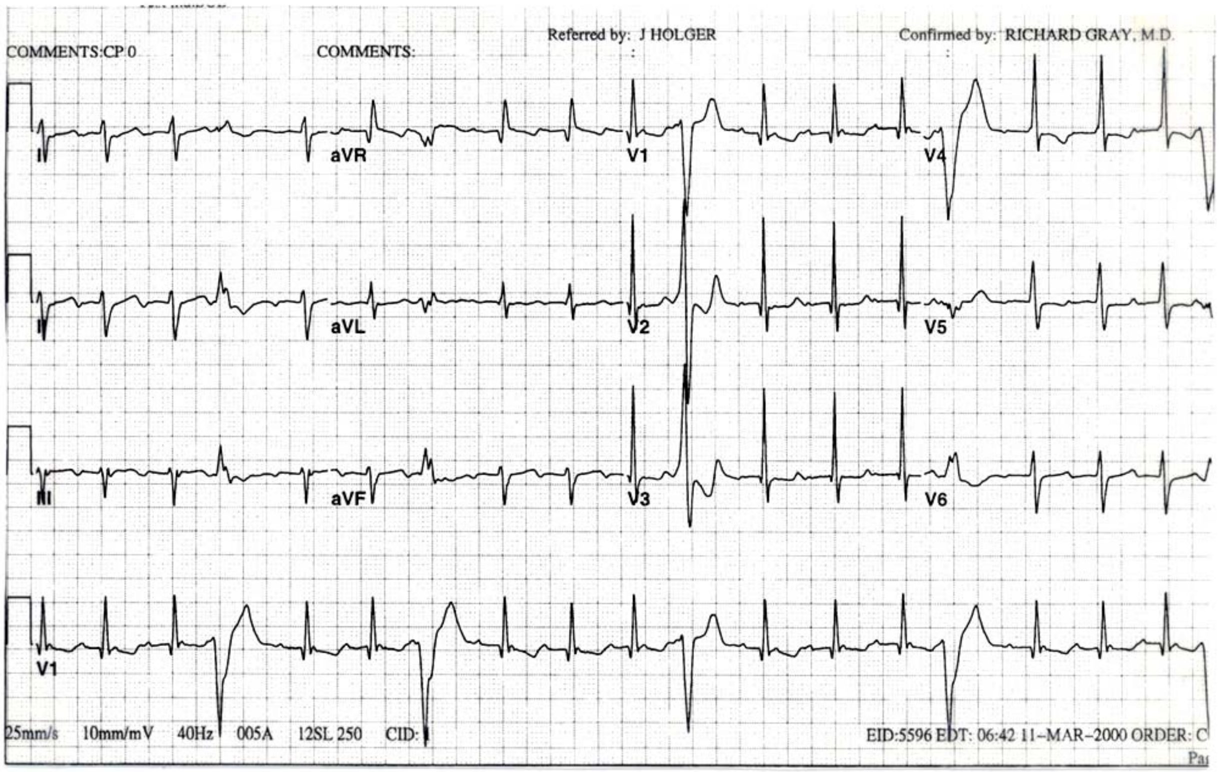
It's time to practice! Take a look at the following 12-lead EKG's and look at each PQRST complex in each of the leads. In the spaces provided after each EKG, write down whether the complexes are normal or abnormal in each lead.

1.



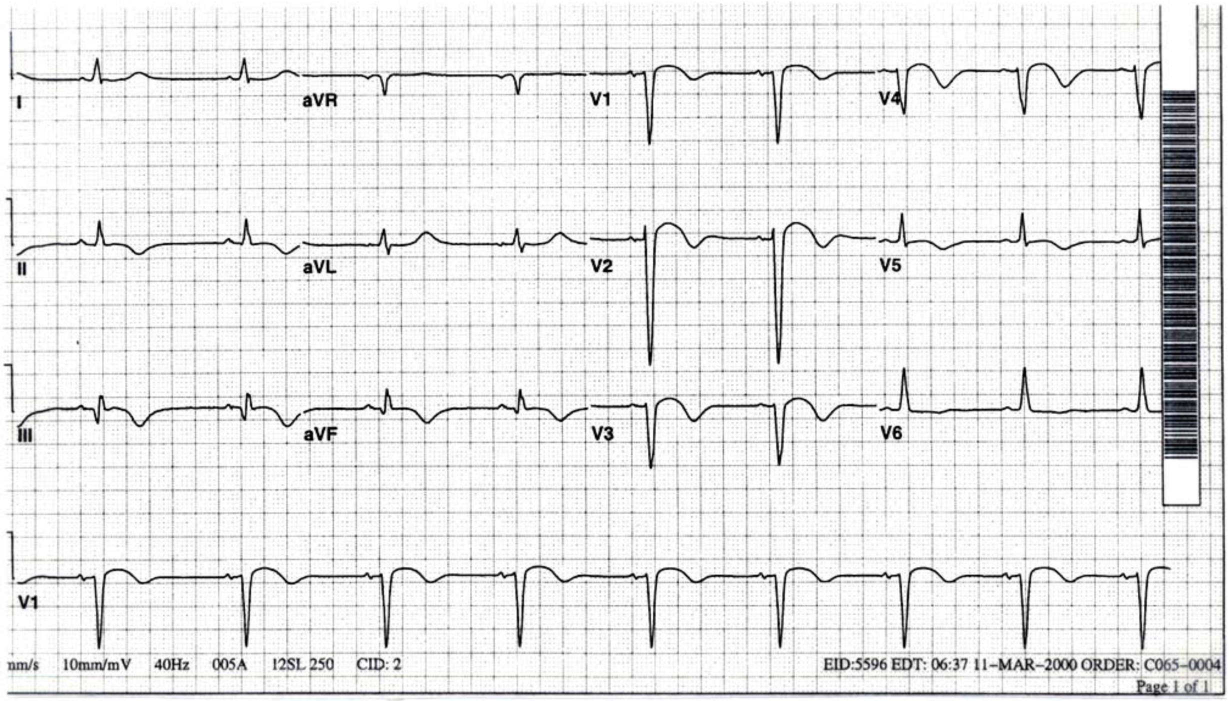
I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**

2.



I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**

3.



I	**aVR**	**V1**	**V4**
II	**aVL**	**V2**	**V5**
III	**aVF**	**V3**	**V6**

Answers to the Practice EKGs

1. I: normal
   II: normal
   III: normal
   aVR: normal
   aVL: normal
   aVF: normal
   V1: normal
   V2: peaked T
   V3: peaked T
   V4: peaked T
   V5: peaked T
   V6: peaked T

   - early transition at V2

2. I: no Q, lg S, T, biphasic T waves
   II: lg S, sm R, T, biphasic T waves
   III: lg S, sm R, inverted T
   aVR: normal
   aVL: normal
   aVF: biphasic T
   V1: biphasic T, QRS upright at V1
   V2: QRS upright at V1
   V3: QRS upright at V1
   V4: depressed ST, QRS upright at V1
   V5: depressed ST
   V6: depressed ST

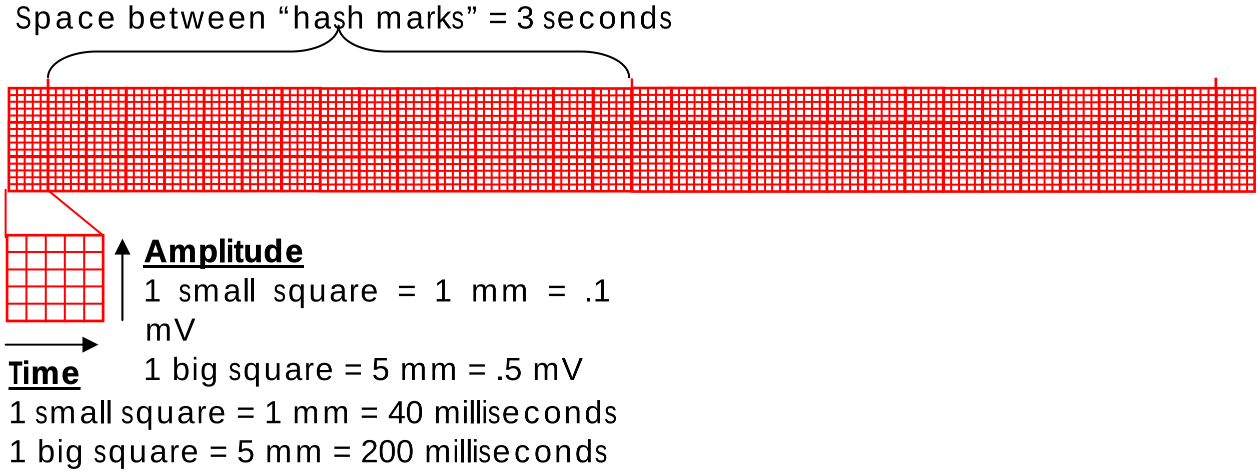
3. I: normal
   II: inverted T
   III: Q wave, elevated ST, inverted T
   aVR: normal
   aVL: normal
   aVF: inverted T
   V1: inverted T
   V2: inverted T
   V3: R<S, inverted T
   V4: R<S, inverted T
   V5: inverted T
   V6: normal

   - late transition at V5

THE ELECTROCARDIOGRAM

In order to interpret the 12-lead EKG, a paper printout is obtained. All EKG 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.



Most of the modern 12-lead EKG machines will be internally calibrated so that the PQRST complexes recorded will be at a standardized height. In other words, when the QRS is not large on the bedside monitor, we can adjust the "gain" or the height of the waveforms. This is helpful for staff to see waveforms the best. The 12-lead, however, depends on a standardized measurement so that the amplitude can be used for measuring the axis and determining chamber hypertrophy.

Most of the 12 lead machines will print out measurements and interpretations. Among the things the machine will do:

- Ventricular rate -- measured in beats per minute
- PR interval -- measured in milliseconds
- QRS duration -- measured in milliseconds
- QT/QTc -- the QT interval and the corrected QT interval in milliseconds
- The P, R, and T axes
- Identify the rhythm
- Identify any chamber enlargement or axis deviation
- Identify any ST segment, T wave, or Q wave abnormalities as seen in ischemia/infarction

Garbage in - garbage out -- the same principle for computers is in place here. The information given to the computer is all that it has to work with. It is very important to place the leads and connect the cables correctly, have the patient lie still with as little respiratory variation as possible, and to correctly input the patients age. There are normal variations with age; if the machine doesn't know the age of the patient, it will designate the variations as abnormal.

STEPS IN INTERPRETING THE 12-LEAD

After you obtain a 12-lead EKG on your patient, what do you do? There is a sequence of steps that are helpful to follow:

1. Assess the rate (atrial and ventricular) and regularity of the underlying rhythm. The 12-lead machine will generally print out a full 12-second strip of the rhythm at the very bottom of the 12-lead. This rhythm strip is generally from either II or V1.

2. Assess the usual intervals and widths: PR interval, QRS width, QT interval.

3. Interpret the rhythm itself.

4. Inspect the P wave:

   - Is it going in the right direction for the lead you're looking at?
   - What is the amplitude and the width?
   - What is the shape of the P wave? Is it diphasic, round, notched, or peaked?

5. Inspect the QRS complex:
   - Is it going in the direction that it should be for the lead you're looking at?
   - What is the amplitude?
   - Are there any Q waves?
   - What is the configuration of the QRS?

6. Inspect the ST segment -- it may be normal if it is one mm above or two mm below the isoelectric line.

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

8. Determine the axis.

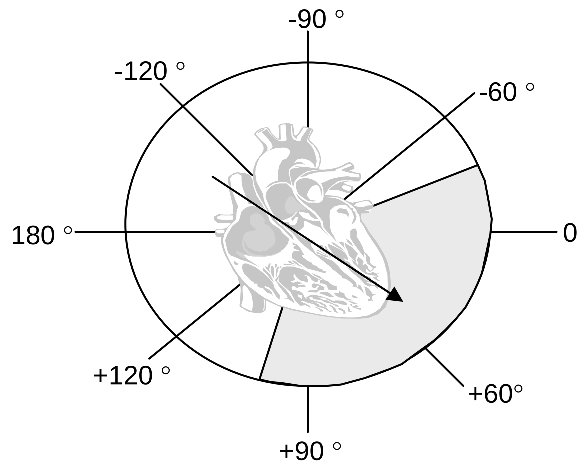
Axis Determination

One of the most confusing, complex, and aggravating parts of the 12-lead EKG to understand is the axis. We will look at what the axis is, what causes it to go astray, and a few practical ways of determining what it is.

What Axis Is

The axis is simply this: the direction of current flow. Each waveform (the P, QRS, and T) has an axis. For all practical purposes, the QRS is the axis that is most important. The QRS axis is an average, or mean, of all electrical flow in the ventricles.

For most people, the QRS axis or vector flows in a direction that puts it between –30 and +105 degrees.

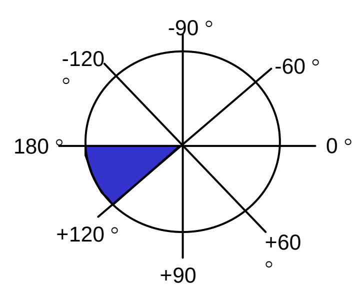


For other people, the current of flow has moved to the right – this is called a **right axis deviation**. The current flow is between +120 and +180 degrees. This deviation indicates that the right ventricle has enlarged and has moved to the left of the chest. Right axis deviation may be normal in very slender adults.

Conditions that may cause right axis deviation include:

- Right ventricular hypertrophy
- Pulmonary conditions, such as pulmonary hypertension, COPD, pulmonary embolism
- Conduction defects, such as left posterior fascicular block and Wolff-Parkinson-White syndrome
- Congenital dextrocardia
- Tricuspid insufficiency
- Pulmonary valve stenosis or insufficiency

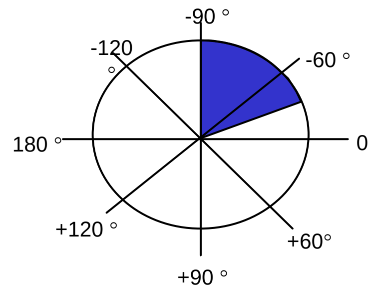
Right Axis Deviation



Left axis deviation is present when the QRS axis is greater than –30 degrees. Although left axis deviation is normal in obese people, many pathologic conditions may cause LAD, including:

- Left ventricular hypertrophy
- Hypertension
- Aortic stenosis
- Conduction defects, such as left anterior hemiblock, Wolff-Parkinson-White syndrome, and left bundle branch block
- Acute inferior MI
- Elevated diaphragm from ascites or pregnancy
- Coarctation of the aorta

Left Axis Deviation



There is a fourth area on the circle: that area between 180 degrees and –90 degrees. This area is called "**no-man's land**" or an **indeterminate axis** or **northwest axis**. This axis is helpful in determining if a wide-complex tachycardia is ventricular or supraventricular in nature.

How To Determine Electrical Axis

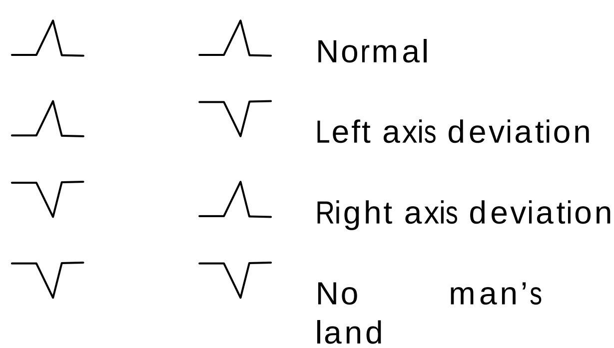
This section will outline three methods of determining QRS axis -- all of which are relatively easy. There are more complex methods of determining the axis; however, with the reliability of the modern 12-lead EKG machines, it is unusual for a practitioner to calculate the exact axis.

Reading the Machine Method

With the advent of the computerized 12-lead machines, and subsequent improvements, the easiest (and probably most accurate) way of determining the axis is by reading the machine print-out. The machine will come up with three numbers: the P wave axis, the QRS axis, and the T wave axis.

Leads I and II Method

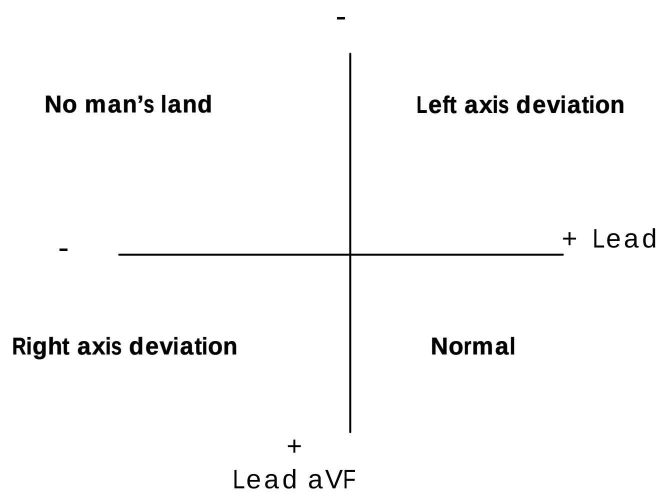
This is the easiest method of determining axis, involving only memorization and the ability to monitor these leads on the bedside monitor. If the QRS complex is biphasic -- some of it is above and some of it is below the isoelectric line -- you will need to count the number of boxes above and below the isoelectric line to determine if the QRS is more positive or more negative.



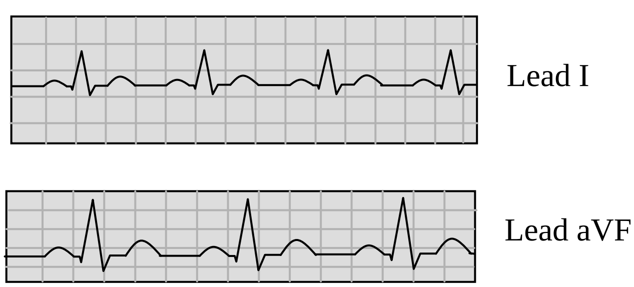
Quadrant Method

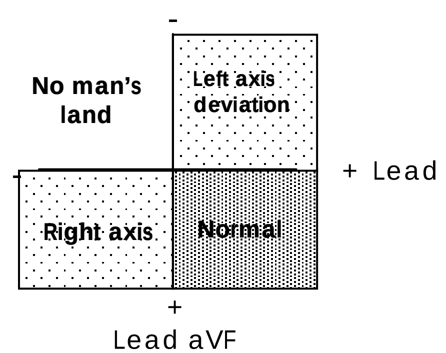
This method requires monitoring for both Lead I and Lead aVF. Looking first at Lead I, determine whether the majority of the QRS complex is positive or negative. If the QRS is mostly positive, shade the area that is to the right of the vertical line. If it is mostly negative, shade to the left of the vertical line. You may need to count the number of small boxes above and below the isoelectric line to determine whether the QRS is more positive or more negative.

Next, look at Lead aVF. If the QRS complex is positive, shade the underneath the horizontal line. If it is mostly negative, shade on top of the horizontal line. The area where two shaded areas meet is the axis determination.



In the following example, Lead I is mostly positive and aVF is mostly positive. The right of the vertical line was shaded, as was underneath the horizontal line. The intersecting quadrant was normal.

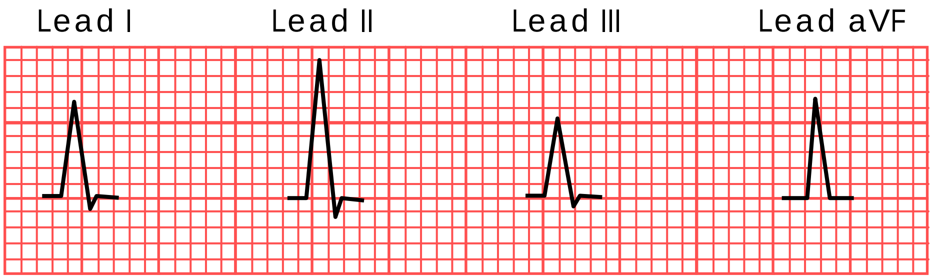




PRACTICE

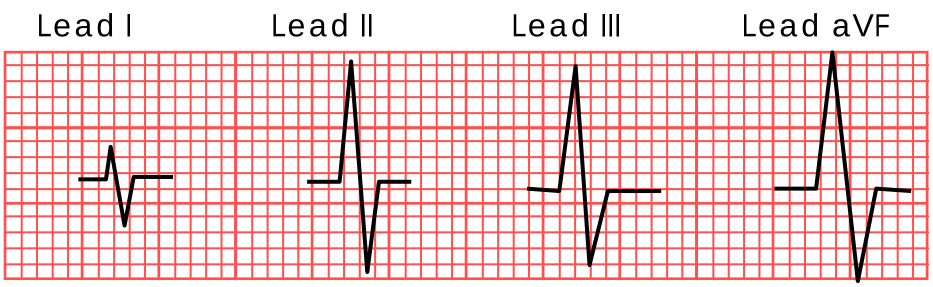
For each of the sets of QRS complexes below, calculate the QRS axis using both methods. Check your answers on the page following the practice sets!

1.



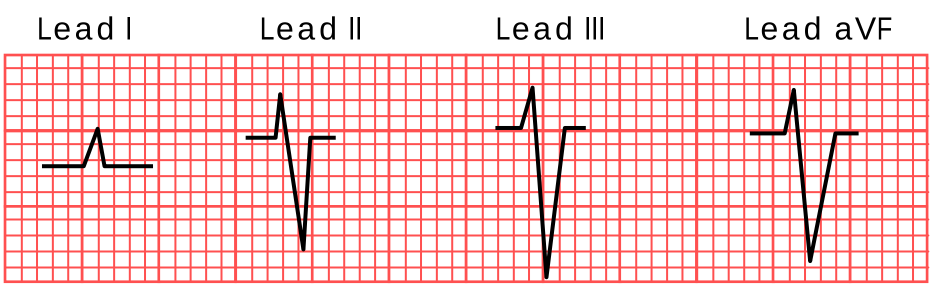
Leads I & II Method ____________________
Quadrant Method ________________________

2.



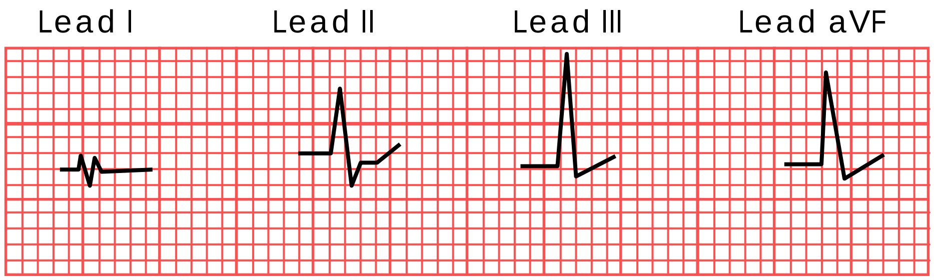
Leads I & II Method ____________________
Quadrant Method ________________________

3.



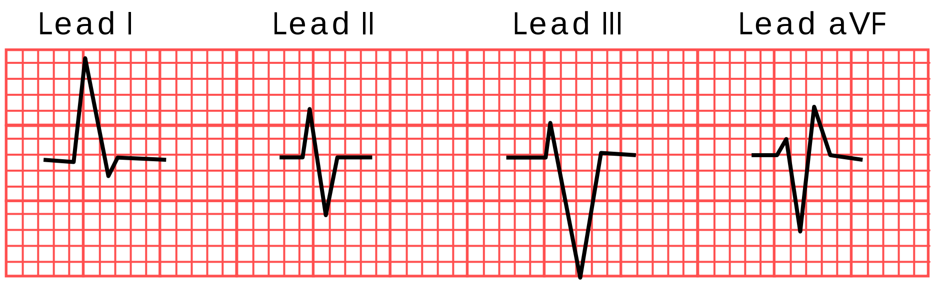
Leads I & II Method ____________________
Quadrant Method ________________________

4.



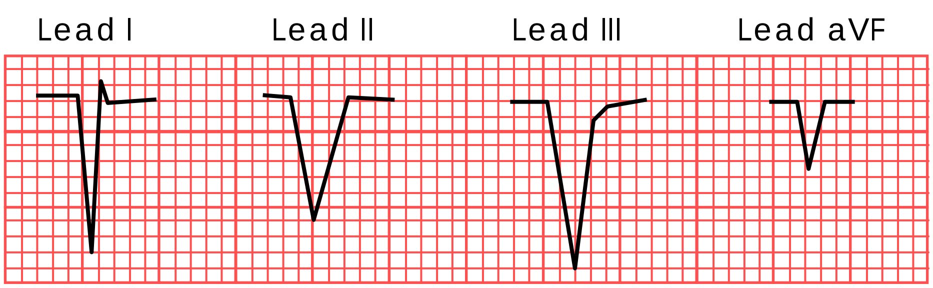
Leads I & II Method ____________________
Quadrant Method ________________________

5.



Leads I & II Method ____________________
Quadrant Method ________________________

6.



Leads I & II Method ____________________
Quadrant Method ________________________

Answers to the Axis Practice Questions

1. Leads I & II Method: ***Normal axis***
   Quadrant Method: ***Normal axis***

2. Leads I & II Method: ***Right axis deviation***
   Quadrant Method: ***Right axis deviation***

3. Leads I & II Method: ***Left axis deviation***
   Quadrant Method: ***Left axis deviation***

4. Leads I & II Method: ***Normal***
   Quadrant Method: ***Normal***

5. Leads I & II Method: ***Left axis deviation***
   Quadrant Method: ***Left axis deviation***

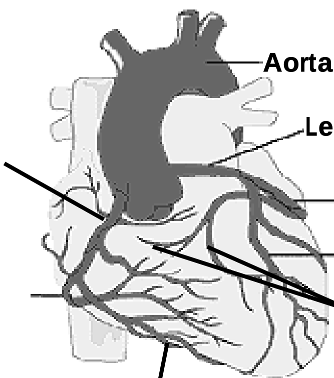
6. Leads I & II Method: ***No man's land***
   Quadrant Method: ***No man's land***
   Comments: ***An axis in "no man's land" usually indicates a ventricular origin of the QRS. Look to see if the QRS complex is wide.***

MONITORING FOR MYOCARDIAL ISCHEMIA

One of the prime reasons for performing a 12-lead EKG is to assess for myocardial ischemia, injury, or infarction. If myocardial hypoxia is suspected, the practitioner should look closely at all 12 leads, paying particular attention to those leads that show T wave inversion, ST segment changes, or Q wave development.

Coronary Blood Supply

Every cell and every tissue in the body needs oxygen. The heart is no exception. The heart receives oxygenated blood through a series of arteries, called the coronary arteries. The coronary arteries originate in the coronary ostia, located just under the flaps of the aortic valve. Because they are compressed during systole, coronary artery filling primarily occurs during diastole.



The RCA

The right coronary artery provides blood to the right atrium, right ventricle, and part of the interventricular septum. The first branch of the RCA is called the acute marginal branch, and it supplies the inferior surface of the right ventricle. In about 85% of people, the RCA also branches into the posterior descending artery, which supplies the right ventricular and the inferior wall of the left ventricle. The RCA and its branches supply the SA node in about 55% of hearts, and the AV node in 90% of hearts.

The LMCA

The left main coronary artery is quite short (1 - 25 mm) and branches almost immediately into the left anterior descending (LAD) and circumflex arteries.

LAD

The LAD supplies much of the left ventricle -- the anterior two thirds of the interventricular septum, the anterior wall of the left ventricle, the right bundle branch, and part of the left bundle branch.

Circumflex

The circumflex (usually referred to as the "circ") supplies the AV node in the remaining 10% of hearts and the SA node in 45% of hearts. The obtuse marginal branch (OMD) of the circumflex artery -- not seen in the diagram -- runs around the back of the left heart and supplies the lateral and posterior surface of the LV.

The other branch that may arise from the circumflex is the posterior descending artery (PDA) -- this occurs in about 15% of people.

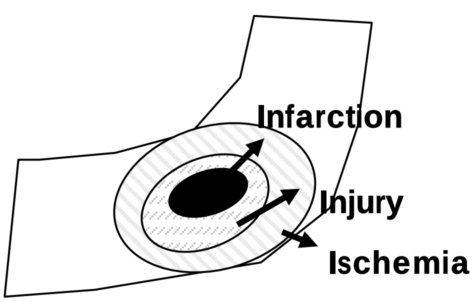
Collateral Circulation

Over time, connections between the different arteries are made. This is a beneficial thing! With collateral circulation, an occlusion of one artery does not mean that the entire distal myocardium will be deprived of oxygen. Collateral connections -- or anastomoses -- go throughout the entire thickness of the myocardium, but the greatest number of collaterals are found near the endocardial surface.

What speeds up collateral development? Increases in oxygen demand -- atherosclerotic heart disease, chronic anemia, hypoxia, hypertension, cardiomyopathy.

What's the downside of collateral circulation? Collateral vessels work well in supplying the heart with oxygen at rest, but the effectiveness of this circulation is lost when the myocardial oxygen consumption (MVO_2) increases with exercise.

The Pathophysiology of Myocardial Ischemia, Injury, and Infarction



There are three degrees of hypoxia in tissues: ischemia, injury, and infarction. If injury is present, so is ischemia. If infarction is present, ischemia and injury are also -- like a big bruise: purple on the inside, gradually getting lighter on the outer edges.

1. **Ischemia** is the result of inadequate blood or oxygen supply to the myocardium. ECG changes in repolarization are seen due to changes in the electrical potential of cells in the ischemic area.

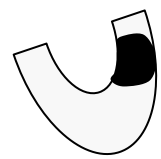
2. The second degree of hypoxia is **injury**. Changes in the ECG are related to incomplete depolarization in the injured area. The injured area becomes more positive than the other tissue because of the release of hydrogen ions (H+) from damaged cells, so the electrical impulse will travel toward that positive area.

3. The final degree of myocardial hypoxia is **infarction**. An infarction means that the cells die from lack of blood supply and/or oxygen. The area of death becomes electrically silent, causing the electrode that faces the area to record an abnormal negative deflection.

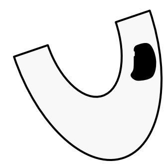
Types of Myocardial Infarctions

One way of categorizing myocardial infarctions is to determine the extent of the damage in terms of the number of layers the hypoxia has affected.

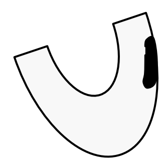
1. The ***transmural*** MI is one in which the entire thickness of the muscle wall is affected -- the epi, myo, and endocardium. This type of MI gives us the biggest EKG changes.



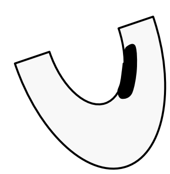
2. The ***intramural*** MI occurs only within the myocardium and does not affect the epicardium or endocardium. This type of MI is not common.



3. The third type is a ***subepicardial*** MI -- an MI in which damage to the epicardium (the outer layer) is seen. Again, this type of MI is not common.



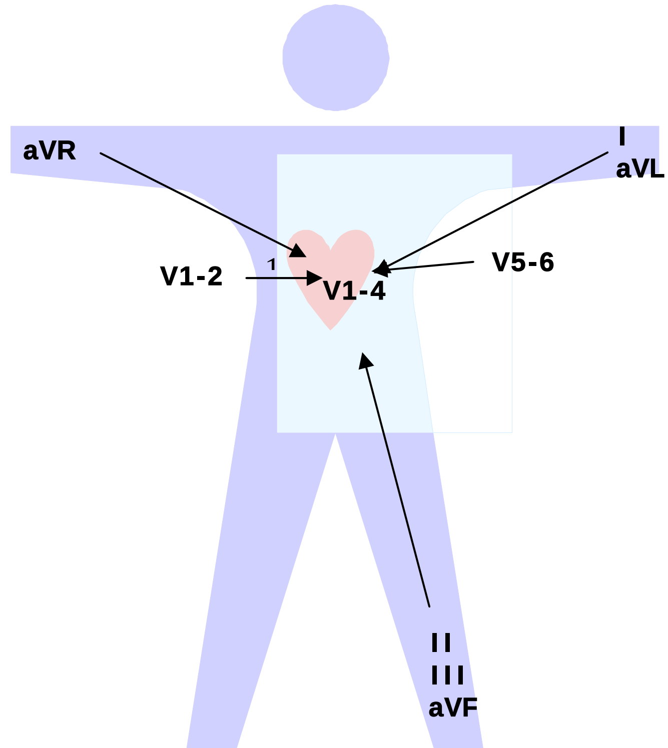
4. And last, the ***subendocardial*** MI entails involvement of the inner layer of the cardiac wall only. This layer of the heart has a poorer blood supply than the other layers and so is more vulnerable to decreased blood supply. Why doesn't it have a good blood supply? First, during systole, the blood vessels in this layer of the heart get very, very compressed. Diastole is the only time that the subendocardial vessels are perfused. Second, the subendocardial vessels can only dilate to a certain extent, and when the other layers of the heart are starved, they will actually steal blood away from the subendocardial vessels. This type of MI is of particularly concern to practitioners because of the lack of good 12-lead signs.



The Eyes of the 12-Leads

The leads that look at specific parts of the heart can be grouped together. The groups of leads include the:

- Inferior leads: II, III, aVF
- Anterior leads: V1-V4
- Lateral leads: I, aVL, V5-V6
- Posterior leads: V1-V3



Looking At the Heart

Imagine that the bipolar and unipolar leads are like eyes -- they look up or down at the area of the myocardium.

- Lead aVR looks primarily at the right atrium; it is the least useful of all of the 12 leads.

- Leads I and aVL look from the left arm toward the lateral wall of the left ventricle.

- Leads II, III, and aVF all look up toward the inferior wall of the left ventricle.

- Leads V1 and V2 look through the heart to the interventricular septum and left ventricle. In combination with V_3 and V_4, these four leads can see the bulk of the anterior left ventricle.

- Lastly, V_5 and V_6 look directly into the lateral wall of the left ventricle.

You may notice that there are no leads that look directly at the right ventricle. This is because the left ventricular electrical current overpowers that of the right and the size of the left ventricle. Special leads, known as V_1-$_6$R need to be placed on the right side of the chest to assess the right ventricle.

SUMMARY

This independent-learning activity was designed to give you some of the basic principles of 12-lead EKG interpretation. Understanding what happens electrically in the heart, what each lead of the 12-lead EKG monitors, which leads reflect the different parts of the heart, and how to determine the QRS axis will start you on the path to understanding 12-lead EKGs.

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 $15.00. 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.

Advanced 12-Lead EKG 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) Which phase of the action potential would lidocaine affect?
   a) 0
   b) 1
   c) 2
   d) 3

3) Calcium channel blockers affect what phase of the action potential?
   a) 0
   b) 1
   c) 2
   d) 3

4) If the lead current flows in the same direction as the mean vector in the heart, the waveform will be:
   a) upright
   b) downward
   c) flat
   d) I don't know

5) If the lead current flows in the opposite direction as the mean vector of flow in the heart, the waveform will be:
   a) upright
   b) downward
   c) flat
   d) I don't know

6) 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

7) The P wave should be:
   a) less than 0.11 seconds in duration
   b) Less than 3 mm in height
   c) round and smooth
   d) all of the above

8) In the precordial leads, the height of the QRS should be less than:
   a) 10 mm
   b) 20 mm
   c) 30 mm
   d) 40 mm

9) A "q" wave is normal in which leads?

a) II, aVF
b) I, aVL
c) V1, V3
d) aVR, II

10) A "q" wave is abnormal if it is:

a) < 0.03 seconds in width
b) > 0.04 seconds in width
c) seen in leads V5 and V6
d) none of the above

11) All waveforms in Leads I, II, and III should be:

a) upright
b) downward
c) flat
d) I don't know

12) The QRS complex in V3 or V4 may be biphasic. This is known as the:

a) midpoint
b) transition
c) R wave progression
d) baseline

13) What is the normal axis?

a) 30 - 150
b) 35 - 97
c) -30 - +105
d) 105 - 150

14) A slender adult with COPD may have a:

a) right axis deviation
b) left axis deviation
c) axis in "no man's land"
d) none of the above

15) A heavy-set adult with an inferior MI may have a

a) right axis deviation
b) left axis deviation
c) axis in "no man's land"
d) none of the above

16) Which axis may indicate whether a rhythm is supraventricular or ventricular in nature?

a) right axis deviation
b) left axis deviation
c) axis in "no man's land"
d) none of the above

This post test does not contain 12-leads for participants to analyze.

Match the following blood vessels with the part of the heart that they supply:

a) LAD

b) RCA

c) Acute marginal branch

d) Circumflex

e) Obtuse marginal branch

17) right atrium____________

18) right ventricle______________

19) inferior right ventricle___________

20) AV node__________________

21) anterior septum____________

22) lateral/posterior left ventricle____

23) anterior left ventricle________

24) Which leads look at the inferior part of the heart?

a) II, III, aVF
b) V1-V4
c) I, aVL, V5-6
d) V1-V3

25) Which leads look at the anterior part of the heart?

a) II, III, aVF
b) V1-V4
c) I, aVL, V5-6
d) V1-V3

26) Which leads look at the septum?

a) II, III, aVF
b) V1-V4
c) I, aVL, V5-6
d) V1-V3

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.

Evaluation: Advanced 12-Lead EKG 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. Explain when a waveform is upright or negative.					
4. Describe the normal waveforms in each of the 12 leads.					
5. Identify which leads look at which parts of the heart wall.					
6. Identify the axis of the QRS complex in two different ways.					
7. 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**
8. Notice of requirements for successful completion, including purpose and objectives		
9. Conflict of interest		
10. Disclosure of relevant financial relationships and mechanism to identify and resolve conflicts of interest		
11. Sponsorship or commercial support		
12. Non-endorsement of products		
13. Off-label use		
14. Expiration Date for Awarding Contact Hours		
15. 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:*		

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

17. 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