



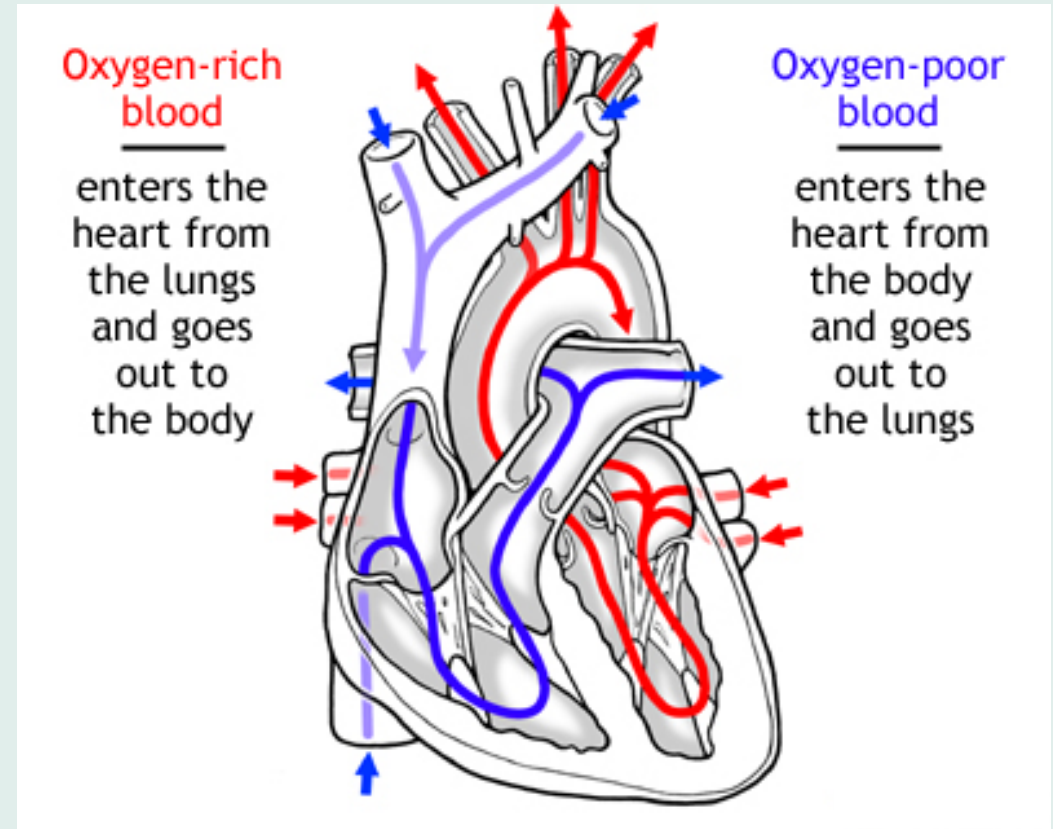
# Electrophysiology: Understanding ECGs

# Pathway of the blood through the heart

Notice how much thicker the walls (made of muscle!) on the **left side** are compared to the right side.

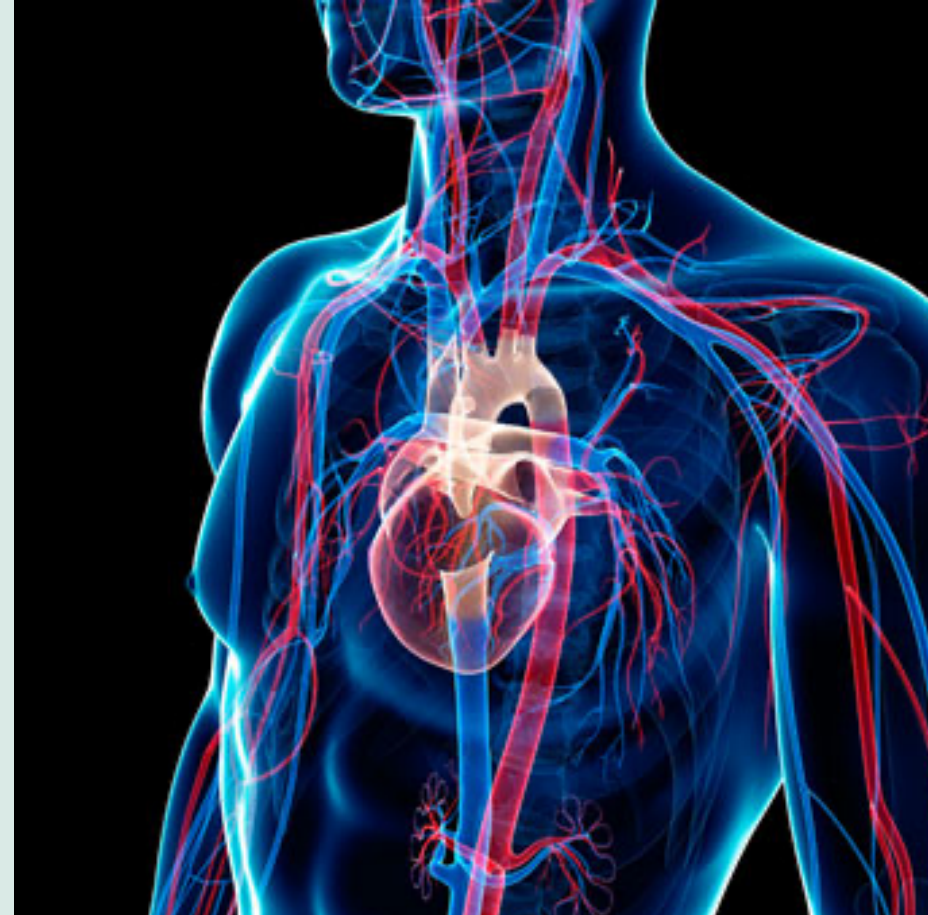
This is because the blood from the left side must be pumped to your limbs, which are very far away!

The blood that leave the right side of the heart travels to the lungs, which is relatively close



# How does the heart move the blood?

- ♦ The heart muscle contracts in a coordinated way, which pumps the blood to where it needs to go.
- ♦ Cardiac electrophysiology is the branch of physiology that studies the electrical properties of the heart.



# Electrophysiology: The Basics

- ♦ The muscles in your body, including the muscles of the heart, contract in response to electrical stimulation by nerves
- ♦ An electrocardiogram (ECG or EKG) is a tracing of the electrical activity that is taking place within the heart.
- ♦ An electrocardiogram (ECG or EKG) assesses heart function by measuring and recording the electrical activity of the heart

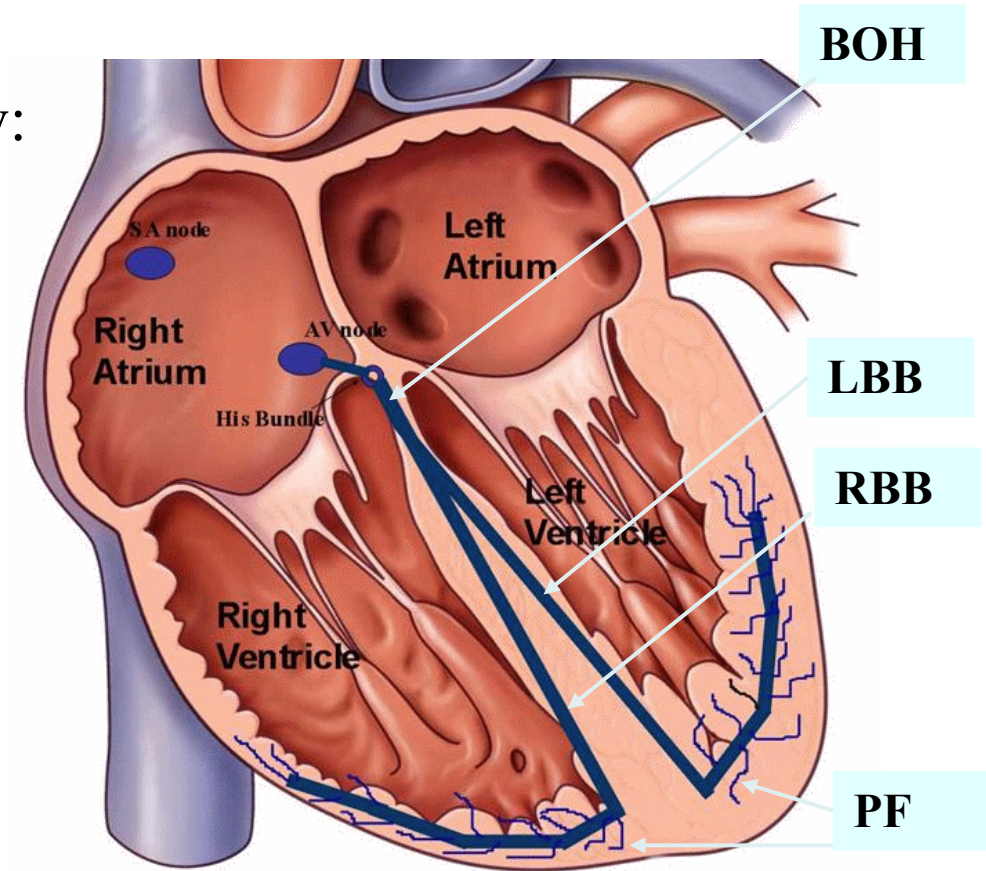




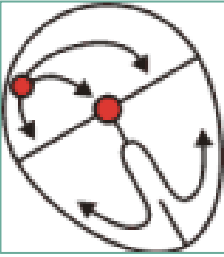
# Impulse conduction: important structures

There are a few important structures to know:

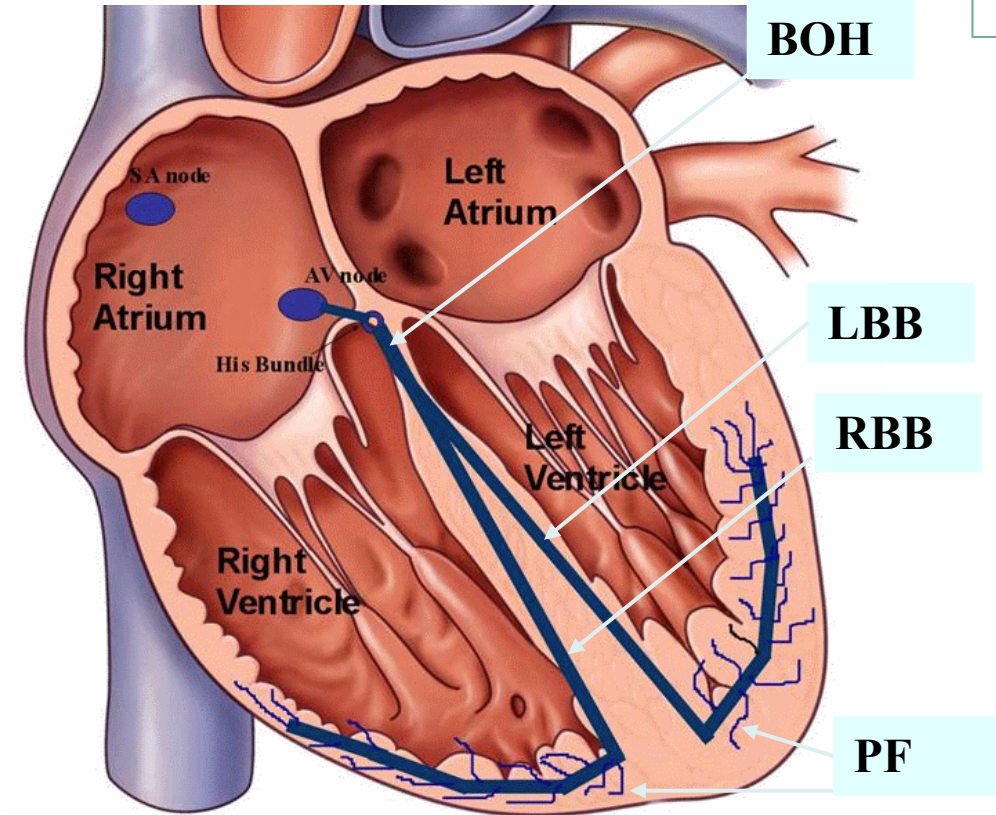
- SA Node
- AV Node
- BOH = Bundle of His
- LBB = Left Bundle Branch
- RBB = Right Bundle Branches
- PF = Purkinje Fibers
- Left & Right Atrium
- Left & Right Ventricle



# Electrophysiology: The basics

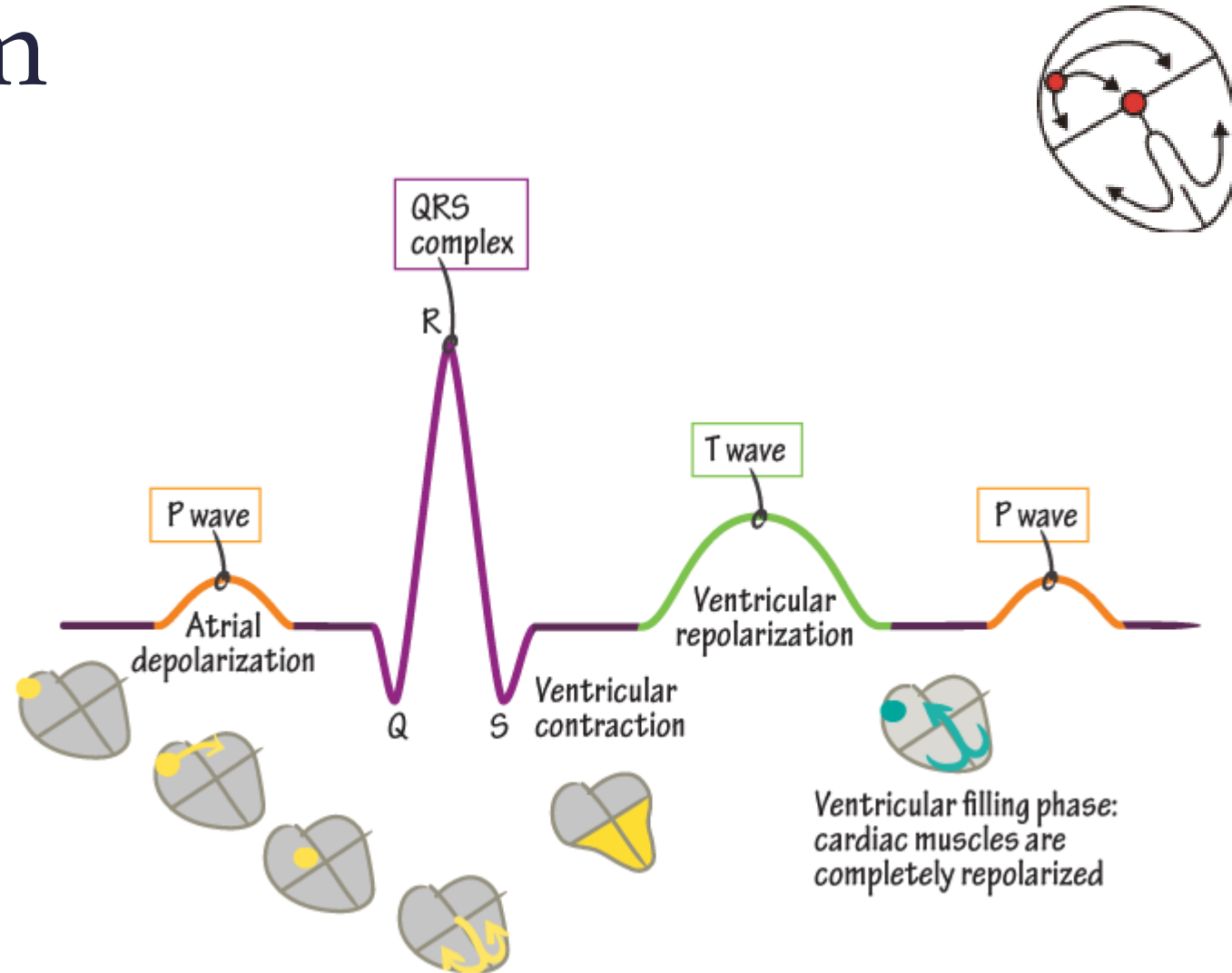


- In a **normal and healthy heart**, an electrical impulse will travel from the SA node, spread across the right atrium, to the AV node, where it then travels down the Bundle of His, the bundle branches, and subsequently the Purkinje Fibers.
- This electrical impulse causes the four chambers of the heart to contract and relax in a coordinated fashion.



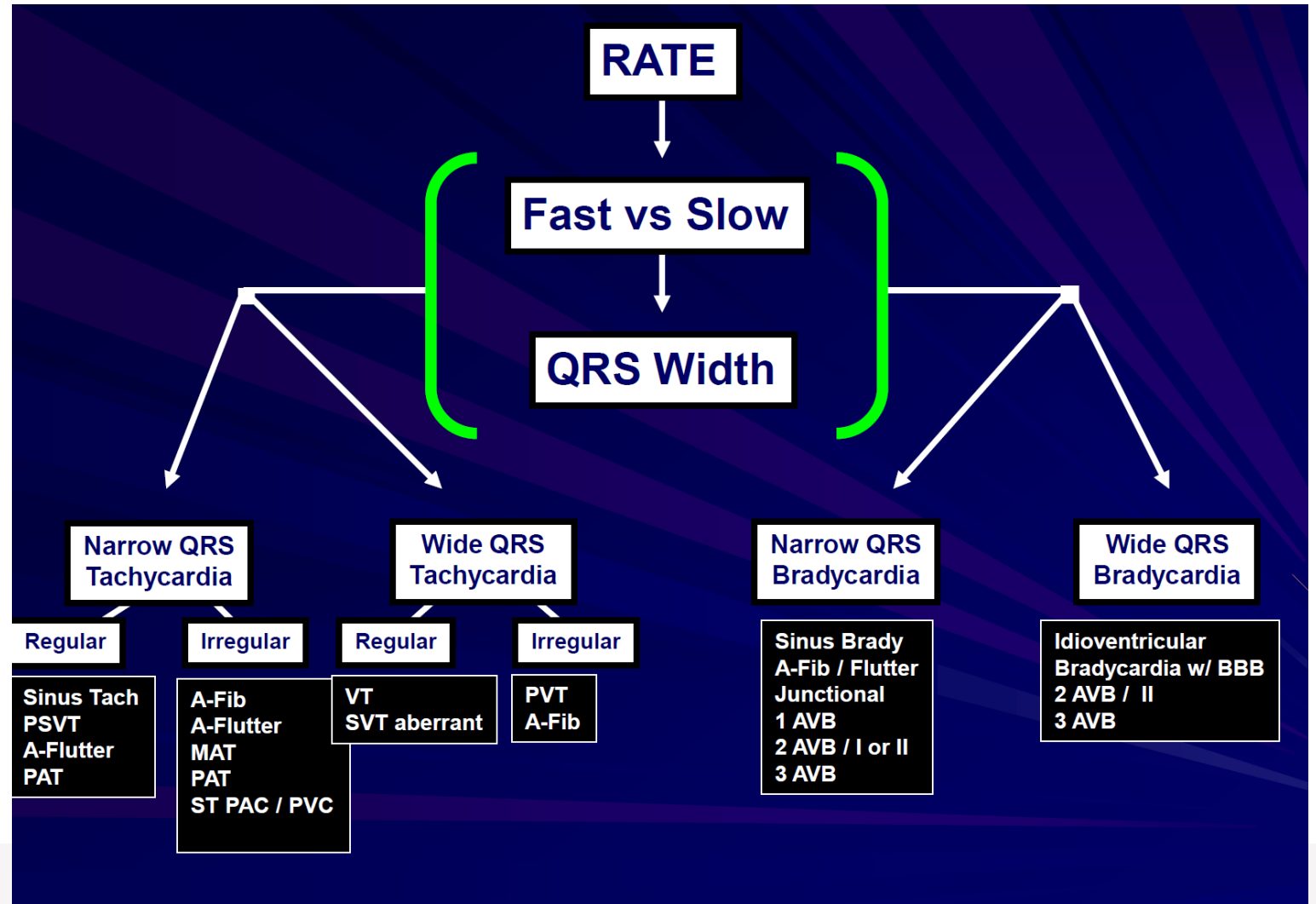
# ECG: Heart Rhythm

- ♦ P-wave= SA node fires causing atrial depolarization
- ♦ PR Interval= impulse moves from atria into the ventricles
- ♦ QRS complex = ventricular depolarization occurs
- ♦ ST segment = part of repolarization (isoelectric phase)
- ♦ T-wave= ventricular repolarization occurs
- ♦ QT Interval= This interval spans the onset of depolarization to the completion of repolarization of the ventricles



# Things to look for in an ECG

- ♦ Rate
- ♦ Rhythm
- ♦ P-waves
- ♦ PR- Interval
- ♦ P and QRS Correlation
- ♦ QRS Rates
- ♦ Pacemaker

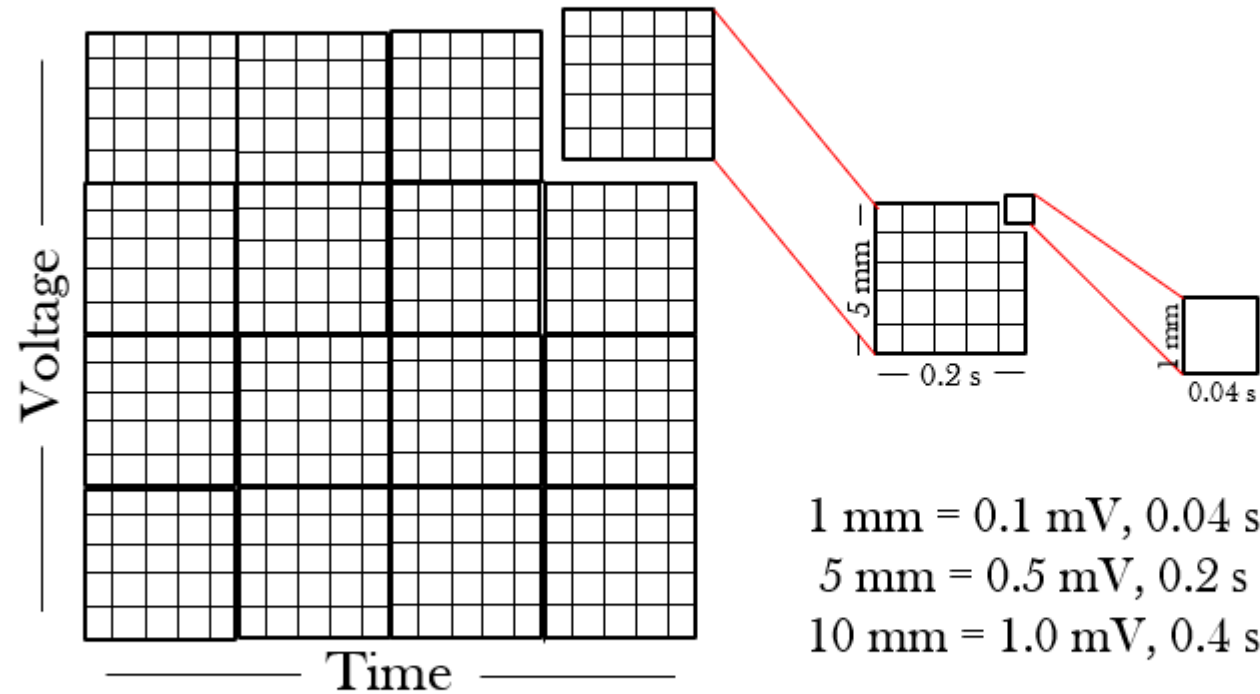




# ECG Interpretation

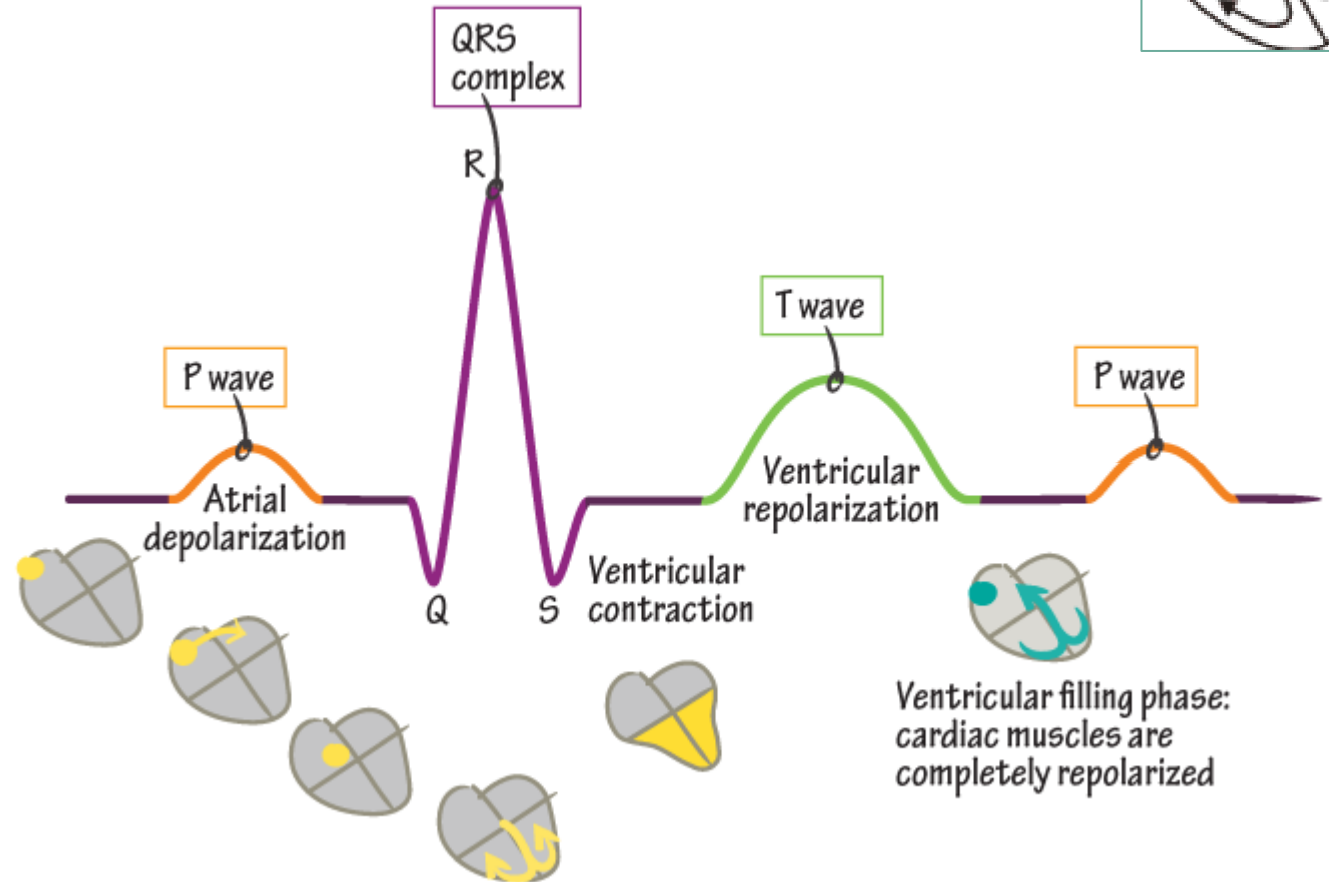


- ECG's are recorded onto graph paper, which is laid out with specific measurements



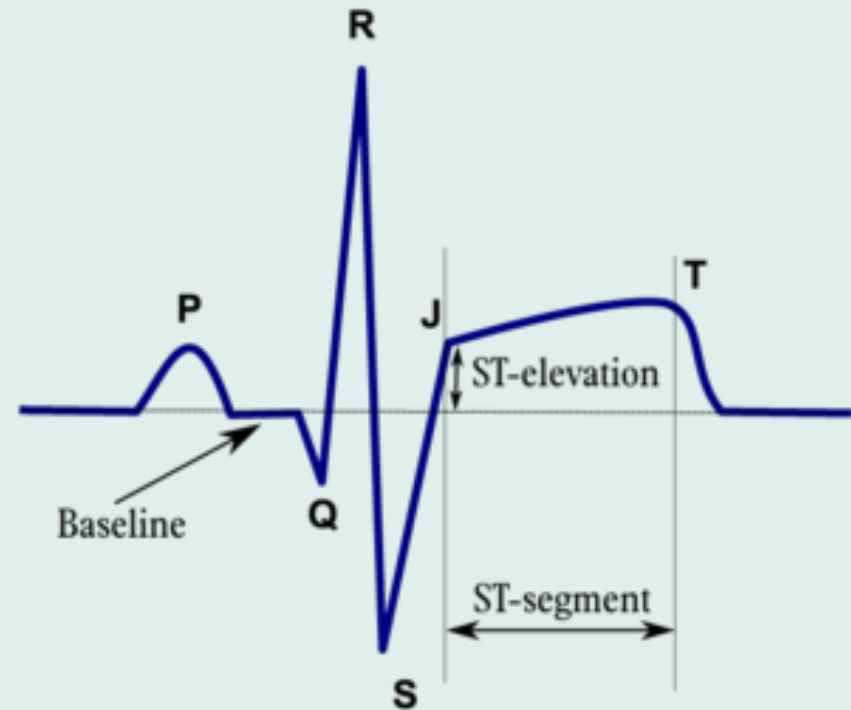
# ECG: What is normal?

- ♦ P-Wave: Atrial depolarization
- ♦ PR Interval (Normal= 0.12-0.2s): Beginning of the P-wave to the onset of the QRS complex
- ♦ QRS Interval (Normal <0.1s): Ventricular Depolarization



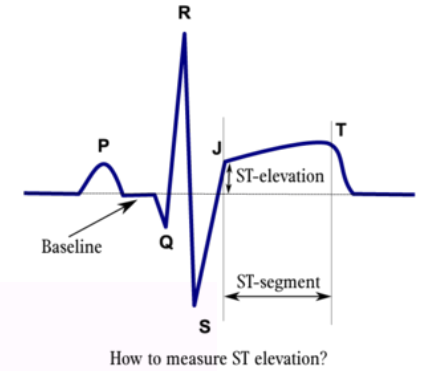
# The ST Segment

- The J point is the the junction between the termination of the QRS complex and the beginning of the ST segment.
- ST depression occurs when the J point is displaced below baseline.
- ST elevation occurs when the J point is displaced above the baseline.
- ST depression and elevation can be used to determine the presence of a cardiac event or an emergent condition.



How to measure ST elevation?

# ST Segment & Heart Attack (MI)



**Table VII**

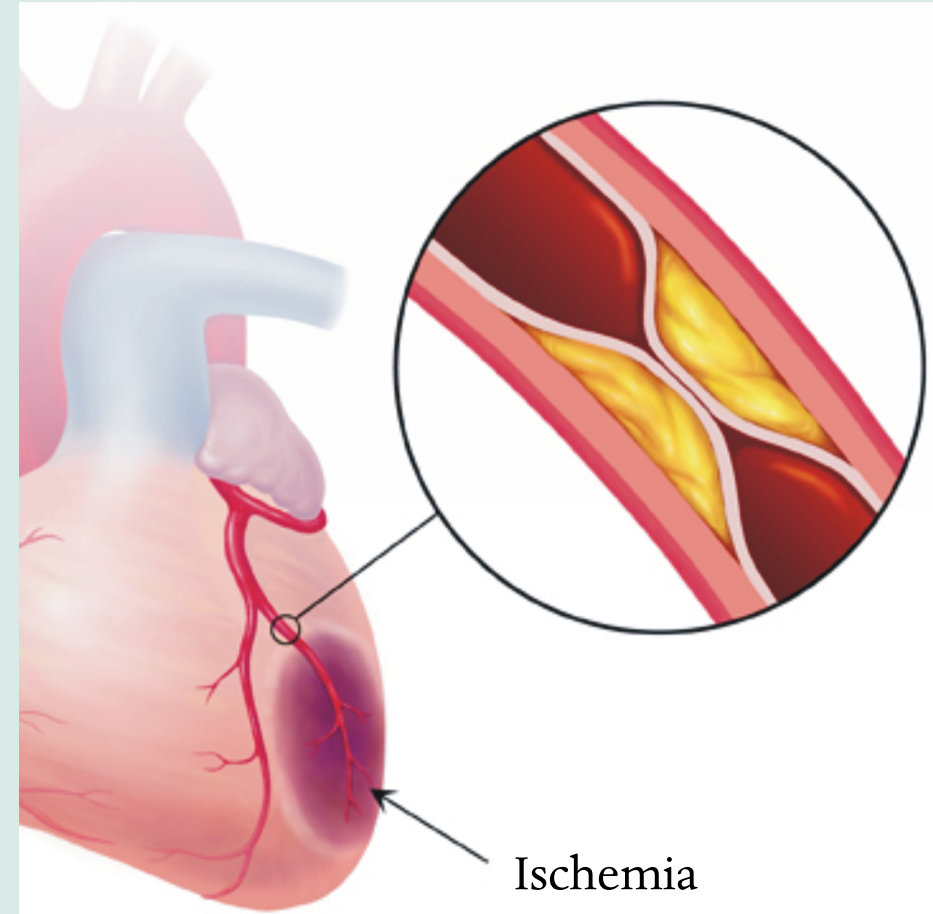
**Myocardial Infarction (MI)**

	<b>ST segment</b>	<b>T wave</b>	<b>Q wave</b>
<b>acute</b>	<b>elevated</b>	<b>normal or inverted</b>	<b>sometimes present</b>
<b>recent</b>	<b>normal</b>	<b>usually inverted</b>	<b>present</b>
<b>old</b>	<b>normal</b>	<b>usually normal</b>	<b>present</b>



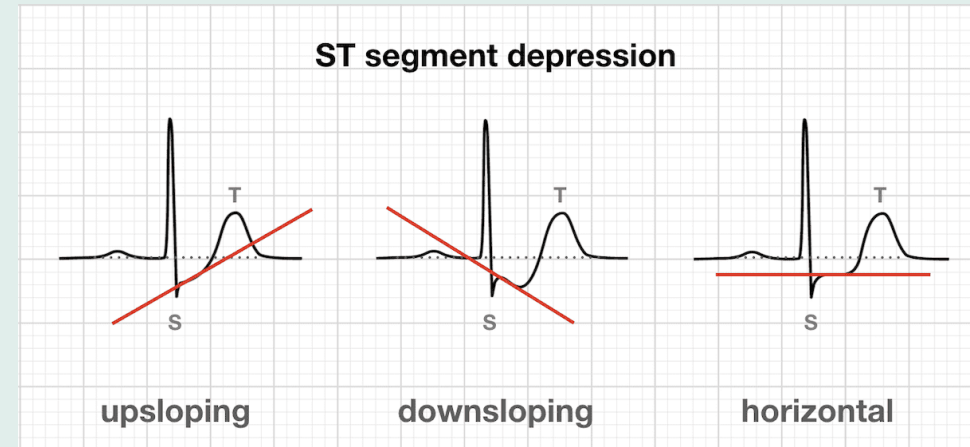
# Ischemia

- ♦ **Ischemia:** A restriction in blood supply, causing a shortage of oxygen that is needed to keep tissues alive.
- ♦ A sudden and-or severe blockage of the coronary (heart) arteries can lead to a heart attack and cause serious abnormal heart rhythms.



# Ischemia

- ♦ Ischemia may be reflected in an ECG by the following changes:
  - ♦ ST segment depression
  - ♦ T-wave inversion or flattening
  - ♦ Prolongation of the QT interval
  - ♦ Appearance of ventricular or supraventricular arrhythmias
  - ♦ Conduction disturbances (AV block, Bundle Branch Block, etc.)
  - ♦ Increase in R-wave amplitude



# Ischemia

Important note!

Not all ST segment depression is considered pathological. It is dependent on the depth of the depression, and on the configuration of the ST segment, whether horizontal, upsloping, or downsloping.

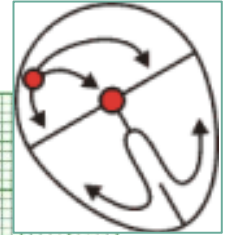
**Schaman's Criteria for ST Segment Depression for Stress Testing Technicians**

ST Configuration	Point of Measurement	ST Depression in mm.
Horizontal	60 msec. [1½ small squares] from J Point	0.5 mm.
Upsloping	80 msec. [2 small squares] from J Point	1.0 mm.
Downsloping	40 msec. [1 small square] from J Point	0.5 mm.

© J. P. Schaman

# Normal Sinus Rhythm

U# 050803084209 8May03 8:42:16 HR:80



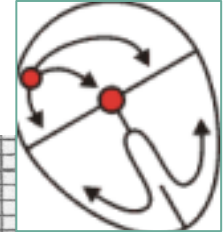
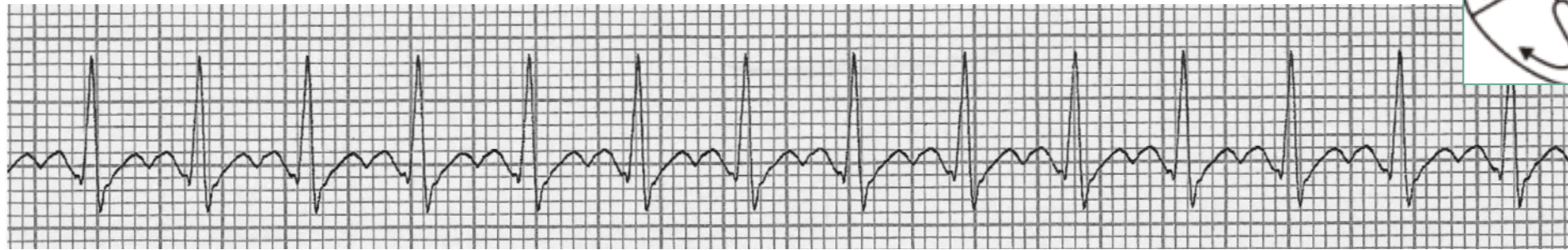
P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>Occurs before each QRS</li><li>Look alike</li></ul>	<ul style="list-style-type: none"><li>Constant and regular</li><li>Interval 0.12-0.2</li></ul>	<ul style="list-style-type: none"><li>Rate 60-100bpm</li><li>Interval = or &lt;0.1s</li></ul>	<ul style="list-style-type: none"><li>Regular</li></ul>	<ul style="list-style-type: none"><li>SA Node</li></ul>



# Types of Arrhythmias: general terminology

- ♦ **Tachycardia:** fast heart rhythm (>100 beats per minute (bpm))
- ♦ **Bradycardia:** slow heart rhythm (< 60 beats per minute (bpm))
- ♦ **Supraventricular arrhythmias:** Begin in the atria (upper chambers of the heart). *Supra* means above; *ventricular* refers to the lower chambers of the heart (ventricles).
- ♦ **Ventricular arrhythmias:** Begin in the ventricles (lower chambers of the heart).
- ♦ **Bradyarrhythmias:** Slow heart rhythms that may be caused by disease in the heart's conduction system, such as the sinoatrial (SA) node, atrioventricular (AV) node or the Bundle of His-Purkinje Fiber network.

# Types of Arrhythmias: Sinus Tachycardia



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>• Occurs before each QRS</li><li>• Look alike</li></ul>	<ul style="list-style-type: none"><li>• Constant and regular</li><li>• Interval 0.12-0.2</li></ul>	<ul style="list-style-type: none"><li>• Rate 100-220bpm</li><li>• Interval: = or &lt;0.1s</li></ul>	<ul style="list-style-type: none"><li>• Regular</li></ul>	<ul style="list-style-type: none"><li>• SA Node</li></ul>

# Types of Arrhythmias: Supraventricular Tachycardia (SVT)

- ♦ SVT is also called paroxysmal atrial tachycardia (PAT).
- ♦ SVT impulses arise from the atrium or above the AV node.
- ♦ Conduction continues along the Bundle of His-Purkinje Fiber system, therefore the QRS shape is typically similar to the QRS shape seen during normal sinus rhythm.

Ex: Supraventricular Tachycardia



Ex: Normal Sinus Rhythm



# Sinus Tachycardia vs. Supraventricular Tachycardia

Sinus Tachycardia	Supraventricular Tachycardia
<ul style="list-style-type: none"><li>• Heart Rate: &lt;220bpm</li><li>• Variable rate/rhythm</li><li>• Gradual onset</li><li>• P-waves are present</li></ul>	<ul style="list-style-type: none"><li>• Heart Rate: &gt;220bpm</li><li>• Minimal variability in rate/rhythm</li><li>• Sudden onset</li><li>• P-waves are absent, abnormal or inverted</li></ul>



# Types of Arrhythmias: Paroxysmal Supraventricular Tachycardia (PSVT)



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>Not easily seen (often buried within the T-wave of the previous beat)</li></ul>	<ul style="list-style-type: none"><li>Difficult to determine due to poorly distinguished P-wave</li></ul>	<ul style="list-style-type: none"><li>&gt;150bpm</li></ul>	<ul style="list-style-type: none"><li>Regular</li></ul>	<ul style="list-style-type: none"><li>Originates above the ventricles, but not driven by the SA Node</li></ul>

# Types of Arrhythmias: Atrial Flutter



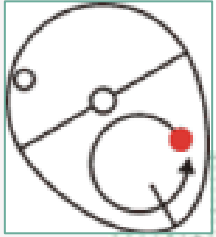
P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>• Saw tooth</li></ul>	<ul style="list-style-type: none"><li>• Variable</li><li>• Difficult to measure</li></ul>	<ul style="list-style-type: none"><li>• Can be slow or rapid</li><li>• Interval: <math>&lt;0.1s</math></li></ul>	<ul style="list-style-type: none"><li>• Both atrial and ventricular complexes are regular (unless a variable block is present)</li></ul>	<ul style="list-style-type: none"><li>• A single re-entrant circuit, where the impulse takes a circular course around the atria</li></ul>

# Types of Arrhythmias: Atrial Fibrillation

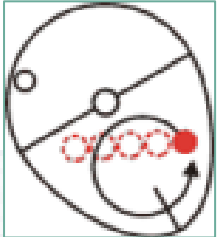
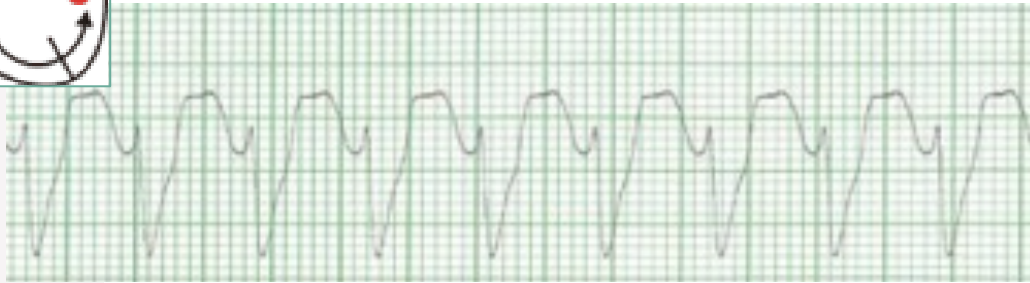


P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>• No distinct P-wave</li><li>• Chaotic “fibrillating” waves</li></ul>	<ul style="list-style-type: none"><li>• Absent/non-discernable</li></ul>	<ul style="list-style-type: none"><li>• Can be slow or rapid</li><li>• Interval: <math>&lt;0.1s</math></li></ul>	<ul style="list-style-type: none"><li>• Both atrial and ventricular complexes are irregularly irregular</li></ul>	<ul style="list-style-type: none"><li>• Occurs from multiple re-entry sites, which results in very rapid atrial rate</li></ul>

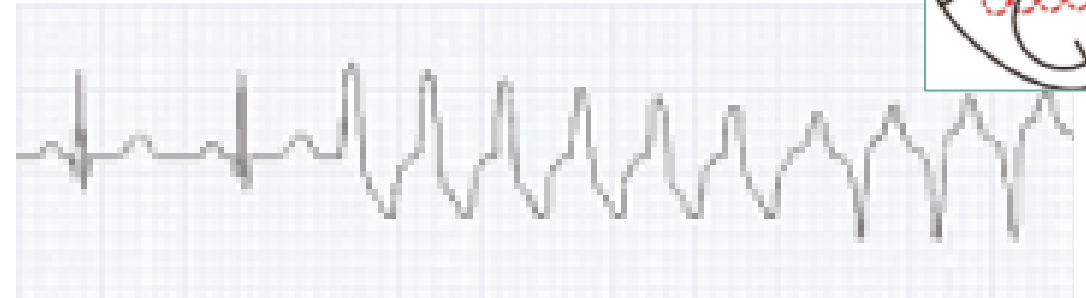
# Types of Arrhythmias: Ventricular Tachycardia



Monomorphic VT



Polymorphic VT



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"> <li>Rare</li> <li>If present, disassociated from the QRS</li> </ul>	<ul style="list-style-type: none"> <li>Absent</li> </ul>	<ul style="list-style-type: none"> <li>Interval is wide (<math>&gt;0.12s</math>) and unusual shape</li> <li><math>&gt;120bpm</math></li> </ul>	<ul style="list-style-type: none"> <li>Monomorphic: usually a similar rhythm</li> <li>Polymorphic: a varied rhythm</li> </ul>	<ul style="list-style-type: none"> <li>Originates in the ventricles</li> </ul>

# Types of Arrhythmias: Ventricular Fibrillation

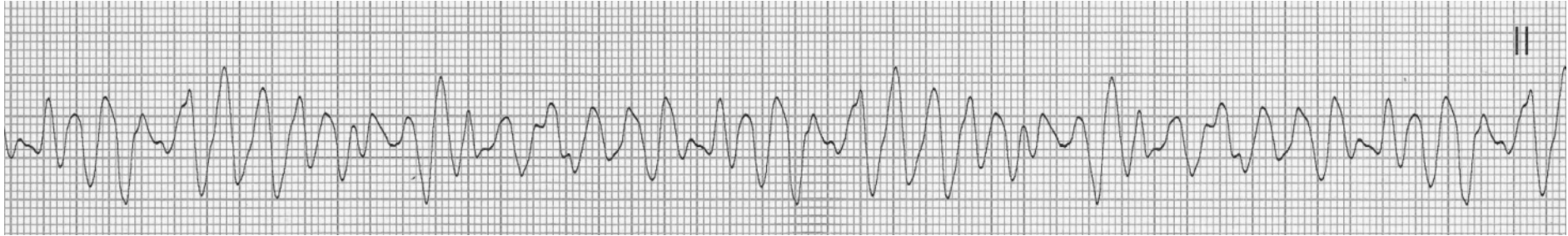


P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>Absent</li></ul>	<ul style="list-style-type: none"><li>Absent</li></ul>	<ul style="list-style-type: none"><li>Chaotic and poorly defined</li><li>Difficult to measure</li></ul>	<ul style="list-style-type: none"><li>Chaotic</li></ul>	<ul style="list-style-type: none"><li>Multiple pacemakers throughout the ventricles</li></ul>

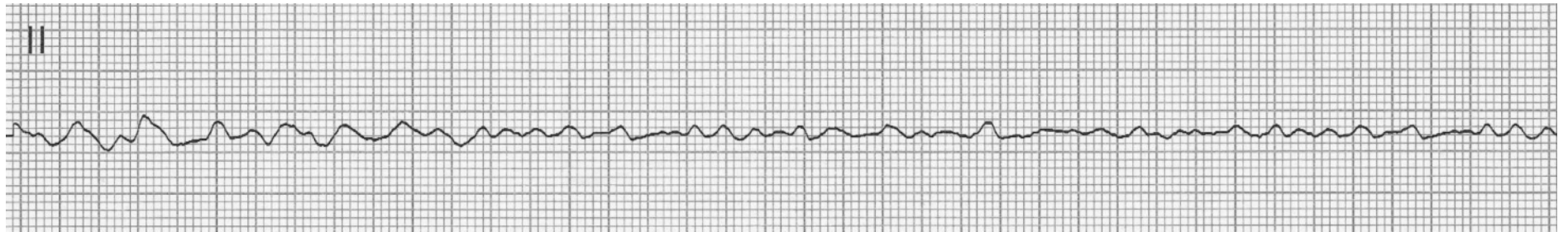


# Types of Arrhythmias: Ventricular Fibrillation

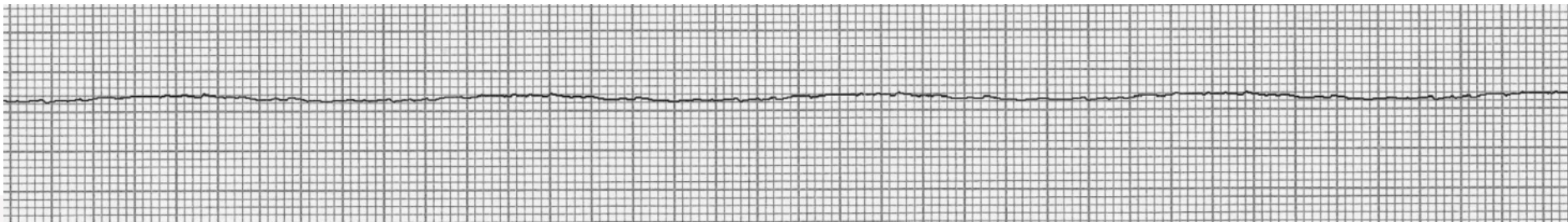
- ♦ Coarse



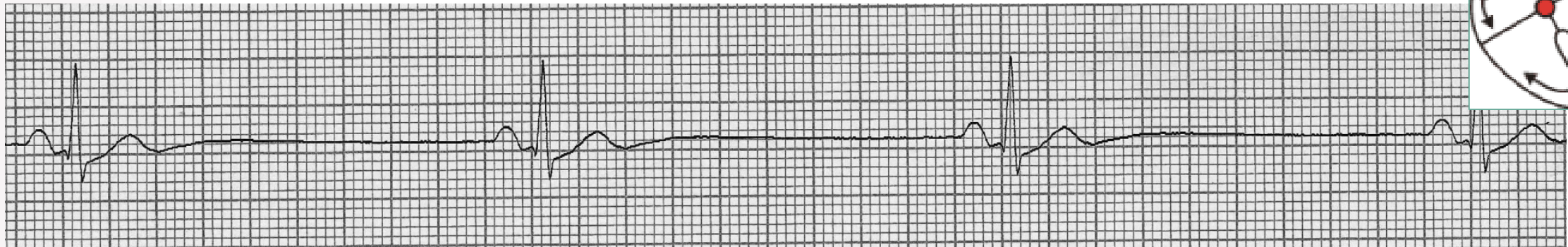
- ♦ Intermediate



- ♦ Fine

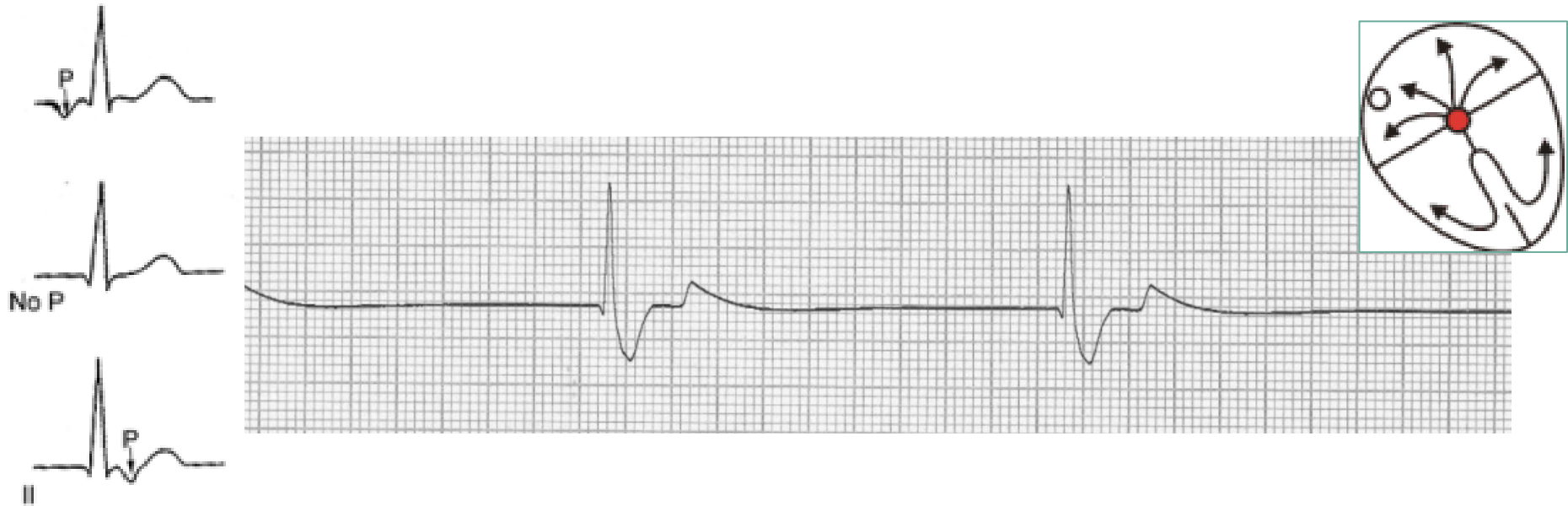


# Types of Arrhythmias: Sinus Bradycardia



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>• Occurs before each QRS</li><li>• Look alike</li></ul>	<ul style="list-style-type: none"><li>• Constant &amp; regular</li><li>• Interval = 0.12-0.2s</li></ul>	<ul style="list-style-type: none"><li>• Rate &lt;60bpm</li><li>• Interval = or &lt;0.1s</li></ul>	<ul style="list-style-type: none"><li>• Regular</li></ul>	<ul style="list-style-type: none"><li>• SA Node</li></ul>

# Types of Arrhythmias: Junctional Rhythms



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"> <li>• Can occur before, during or after the QRS complex</li> <li>• Can be abnormal in size and shape</li> </ul>	<ul style="list-style-type: none"> <li>• Normal or prolonged</li> </ul>	<ul style="list-style-type: none"> <li>• Rate 40-60bpm</li> </ul>	<ul style="list-style-type: none"> <li>• Regular</li> </ul>	<ul style="list-style-type: none"> <li>• The SA node malfunctions</li> <li>• The AV node initiates beats</li> </ul>



# Types of Arrhythmias: Idioventricular Rhythm

During idioventricular rhythm, the SA node and AV node fail to generate an electrical impulse. To compensate, the ventricles generate impulses



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>Absent</li></ul>	<ul style="list-style-type: none"><li>Absent</li></ul>	<ul style="list-style-type: none"><li>Rate 20-40bpm, but can be faster</li></ul>	<ul style="list-style-type: none"><li>Regular</li></ul>	<ul style="list-style-type: none"><li>Ventricles</li></ul>

# Types of Arrhythmias: 1° AV Block



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>• Occurs before each QRS</li><li>• More of a “delay” than a block</li></ul>	<ul style="list-style-type: none"><li>• Constant &amp; regular</li><li>• Interval &gt;0.2s</li></ul>	<ul style="list-style-type: none"><li>• Variable rate</li></ul>	<ul style="list-style-type: none"><li>• Regular</li></ul>	<ul style="list-style-type: none"><li>• SA Node, but with a delay</li></ul>



# Types of Arrhythmias: 2° AV Block

## Type 1 (Wenckebach)



P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>Occasional P-wave not followed by QRS</li></ul>	<ul style="list-style-type: none"><li>Progressive lengthening of the PR interval until the QRS is dropped</li></ul>	<ul style="list-style-type: none"><li>Interval &lt; 0.1s</li><li>Rate ~50-80bpm</li></ul>	<ul style="list-style-type: none"><li>Atrial rate generally faster than ventricular rate (due to the dropped beat)</li></ul>	<ul style="list-style-type: none"><li>Problem at the AV node with increased delay</li></ul>

# Types of Arrhythmias: 2° AV Block

Type 2



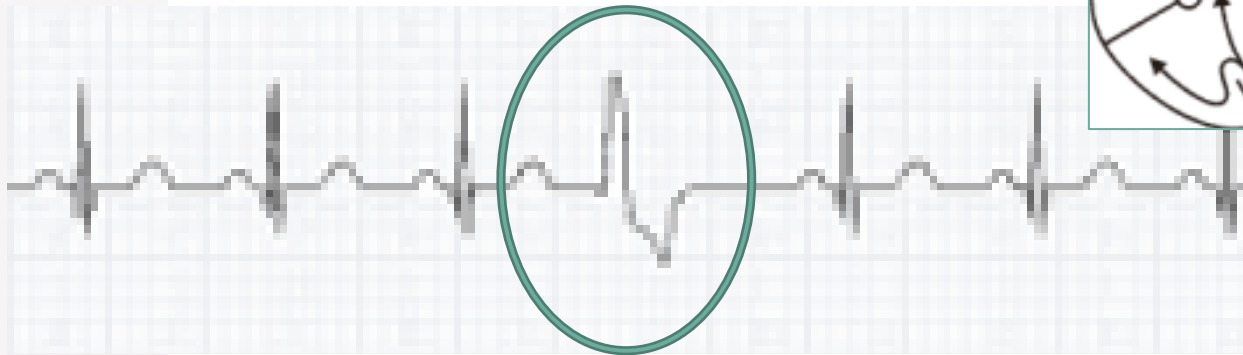
P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"> <li>P-waves may not have corresponding QRS complexes</li> </ul>	<ul style="list-style-type: none"> <li>Intervals remain constant (if QRS present)</li> </ul>	<ul style="list-style-type: none"> <li>Slowed</li> </ul>	<ul style="list-style-type: none"> <li>Atrial rate unaffected</li> <li>Ventricular rate slowed</li> <li>Ventricular irregularities due to blocked beats</li> </ul>	<ul style="list-style-type: none"> <li>Low-level block: &lt;0.1s</li> <li>High level block: &gt;0.12s</li> </ul>

# Types of Arrhythmias: 3<sup>o</sup> AV Block (complete)

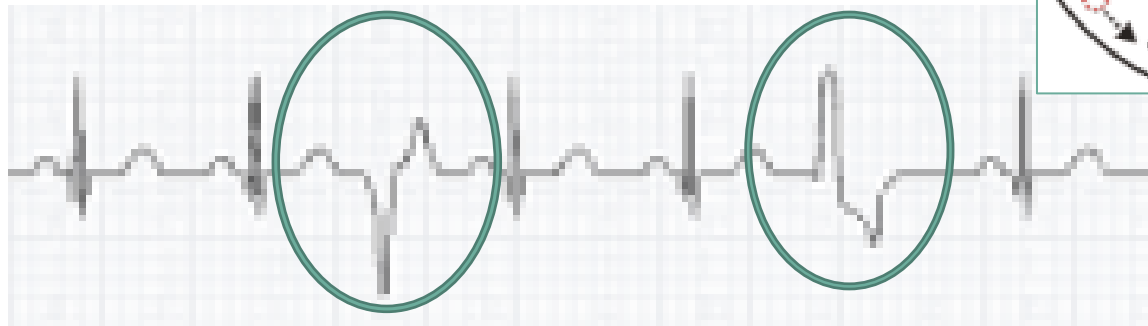


P wave	PR Interval	QRS Complex	Rhythm	Pacemaker
<ul style="list-style-type: none"><li>• Normal</li></ul>	<ul style="list-style-type: none"><li>• No relationship between P-wave and R-wave</li></ul>	<ul style="list-style-type: none"><li>• Atrial rate: 60-100bpm</li><li>• Ventricular rate 20-40bpm</li></ul>	<ul style="list-style-type: none"><li>• Atrial and ventricular complexes are regular but disassociated</li></ul>	<ul style="list-style-type: none"><li>• Damage to the conduction systems means that No impulses can pass</li><li>• Ventricular beats arise</li></ul>

# Types of Arrhythmias: Premature Ventricular Contraction (PVC)



Unifocal PVC



Multifocal (Polymorphic) PVC

# Types of Arrhythmias: Bigeminy & Trigeminy

- ◆ **Bigeminy:** Every other beat is a PVC

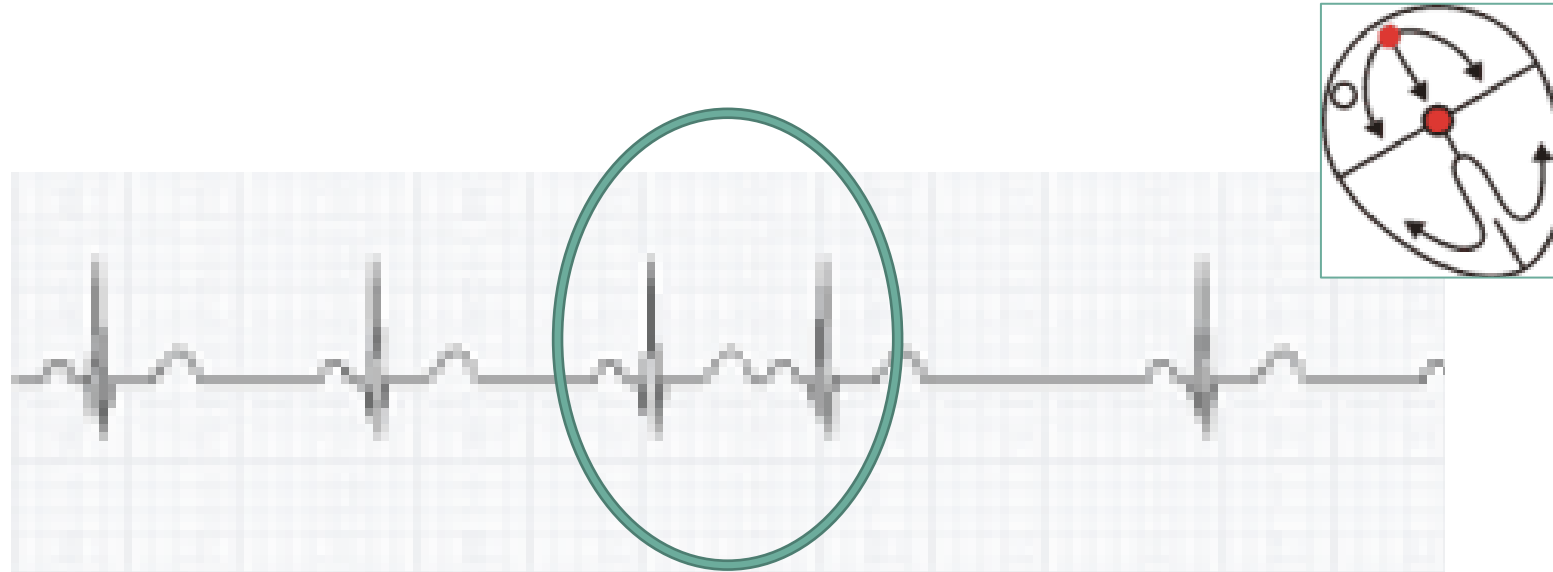


- ◆ **Trigeminy:** Every third beat is a PVC





# Types of Arrhythmias: Premature Atrial Contraction (PAC)



Premature atrial contractions (**PACs**) are premature heartbeats that are similar to PVCs, but instead occur in the upper chambers of the **heart**.

# Symptoms of arrhythmias may include:

- ♦ Palpitations: A feeling of skipped heartbeats, fluttering, "flip-flops" or feeling that the heart is "running away"
- ♦ Pounding in the chest
- ♦ Dizziness or feeling lightheaded
- ♦ Shortness of breath
- ♦ Chest discomfort
- ♦ Weakness or fatigue (feeling very tired)

Note: Not all arrhythmias present with symptoms. An arrhythmia may be **silent (not cause any symptoms)**. A doctor can detect an irregular heartbeat during an examination by taking your pulse, listening to your heart or by performing diagnostic tests.

# Signs of a heart attack



## **Chest discomfort**

Pressure, squeezing,  
fullness or pain, burning or  
heaviness



## **Sweating**

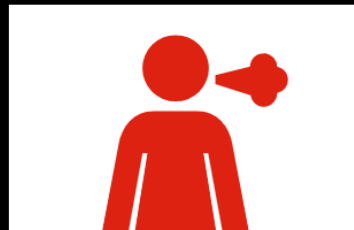


## **Upper body discomfort**

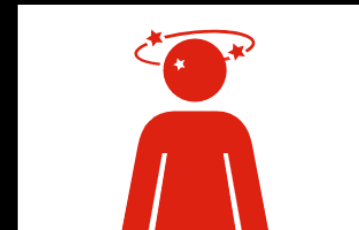
Neck, jaw, shoulder, arms,  
back



## **Nausea**



## **Shortness of breath**



## **Light-headedness**

# Experiencing signs of a heart attack?

## 1. Call 9-1-1

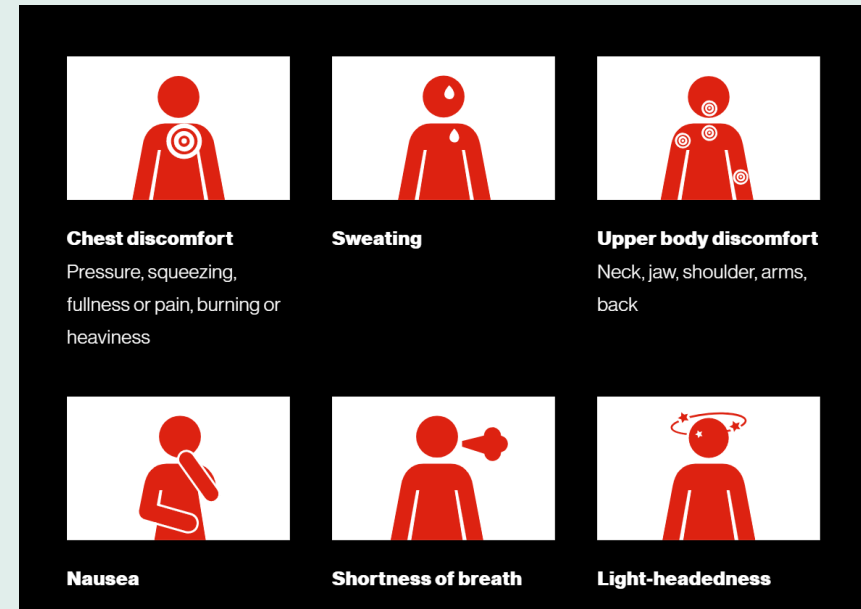
- Or your local emergency number immediately. Emergency personnel can start treatment enroute to the hospital.

## 2. Stop all activity

- Sit or lie down, in whatever position is most comfortable.

## 3. Take your nitroglycerin

- If you take nitroglycerin, take your normal dosage.



# Experiencing signs of a heart attack?

4. **ASA (Aspirin) may be beneficial**
  - ♦ Chew one and swallow one ASA (Aspirin), if you are not allergic or intolerant (either one 325 mg tablet (Adult Aspirin) or two 81 mg tablets (baby Aspirin)).
5. **Rest and wait**
  - ♦ Stay calm while waiting for help to arrive.
6. **Keep a list of your medications in your wallet and by the phone.**
  - ♦ Emergency personnel will want this information.

