



# **PCP Autonomous IV Program**

## **Module I**

# **E.C.G. RHYTHM INTERPRETATION**



# E.C.G. RHYTHM INTERPRETATION

## Authors

### **Mike Muir AEMCA, ACP**

Paramedic Program Manager  
Grey-Bruce-Huron Paramedic Base Hospital  
Grey Bruce Health Services, Owen Sound

### **Kevin McNab AEMCA, ACP**

Quality Assurance Manager  
Huron County EMS

## Reviewers

Rob Theriault EMCA, RCT (Adv.), CCP (F)  
Paramedic Program Manager  
Peel Base Hospital

Kim Arsenault AEMCA, ACP, BSc HK  
Advanced Care Paramedic Coordinator  
Peel Base Hospital

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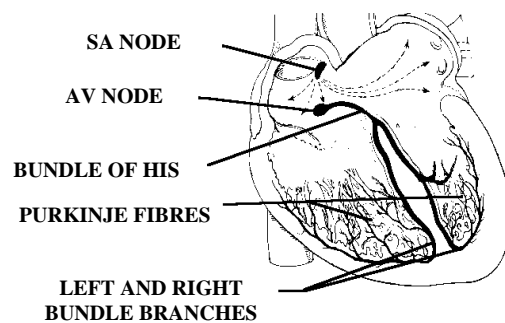
## Section I – Electrophysiology

### Cardiac Conduction System

#### Anatomy and Physiology

The cardiac conduction system is comprised of specialized tissues that unlike muscle tissue located elsewhere in the body can 1: generate electrical impulses (automaticity) and 2: conduct electrical impulses (conductivity). The cardiac muscle tissue is similar to other tissue in its ability to contract (contractility).

Specialized tissue located in the right atria known as the sinoatrial node (SA) is the primary pacemaker of the heart producing electrical impulses at a rate of 60 to 100 per minute in the normal resting heart. The generation of the impulses results from the movement of electrolytes ( $\text{Na}^+$ ,  $\text{Ca}^{++}$  and  $\text{K}^+$ ) across the cell membrane leading to the depolarization of the cell. Other tissue similar in nature to the SA node, the atrioventricular node (AV) is capable of producing the same impulses but at a slower rate, 40 to 60 per minute. Tissues located in the ventricles (bundle branches and Purkinje fibers) can also produce impulses at rates of 20 to 40 per minute.



In addition to the ability to automatically generate electrical impulses, the cardiac conduction system allows for the transmission of the impulses throughout the heart in a coordinated manner, producing the rhythmic contraction associated with normal cardiac output.

Impulses generated by the SA node travel along specialized tissue known as the conduction pathways. The impulse travels to the AV node where it is delayed, allowing for the contraction of the atria. Once the impulse passes through the AV node it transcends the Bundle of His, the Right and Left Bundle Branches and finally the Purkinje Fibres.

#### Conduction Times & Velocities

Conduction times and velocities are important in that they co-ordinate the electrical system of the heart with its mechanical function of a pump. The diagram below shows that the movement of the impulses through the atria (right and left) is significantly slower than the movement through the ventricles. The larger mass of the ventricle requires the rapid flow of the electrical impulses resulting in the complete depolarization and contraction of the entire ventricle at almost the same time. This action results in the forceful contracting of the heart producing cardiac output.

#### Notes:

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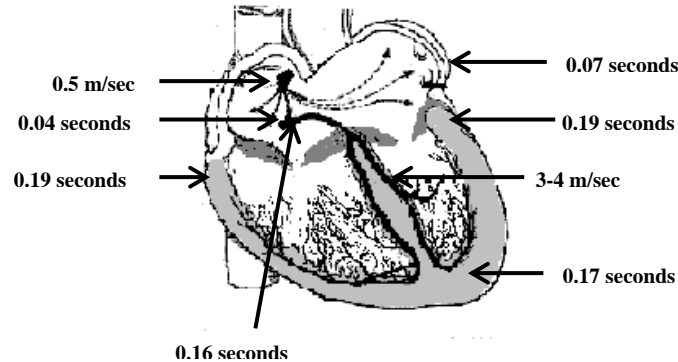
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## Section I – Electrophysiology

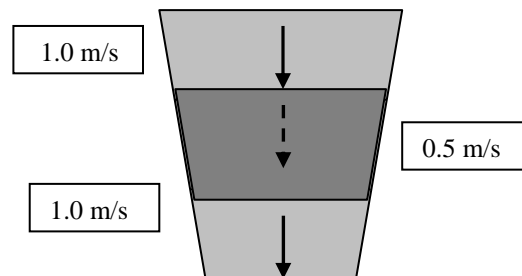
### Cardiac Conduction System (cont'd)

### Conduction Times & Velocities (cont'd)



### Role of the AV Node

The AV Node plays a significant role in delaying the conduction of electrical impulses between the atria and the ventricles. The delay provides sufficient time to allow the ventricle to fully fill with blood and stretch sufficiently prior to the impulses entering the ventricle producing the contraction. The tissue of the AV Node becomes more dense slowing the impulse then breaks through to enter the ventricle.



Because of the unique qualities of the AV nodal tissue and its ability to naturally slow the conduction of impulses, when things go wrong, such as in the diseased or injured heart, the AV Node is responsible for the cardiac arrhythmias involving the heart blocks of the 1<sup>st</sup>, 2<sup>nd</sup>, or 3<sup>rd</sup> degree type.

### Notes:

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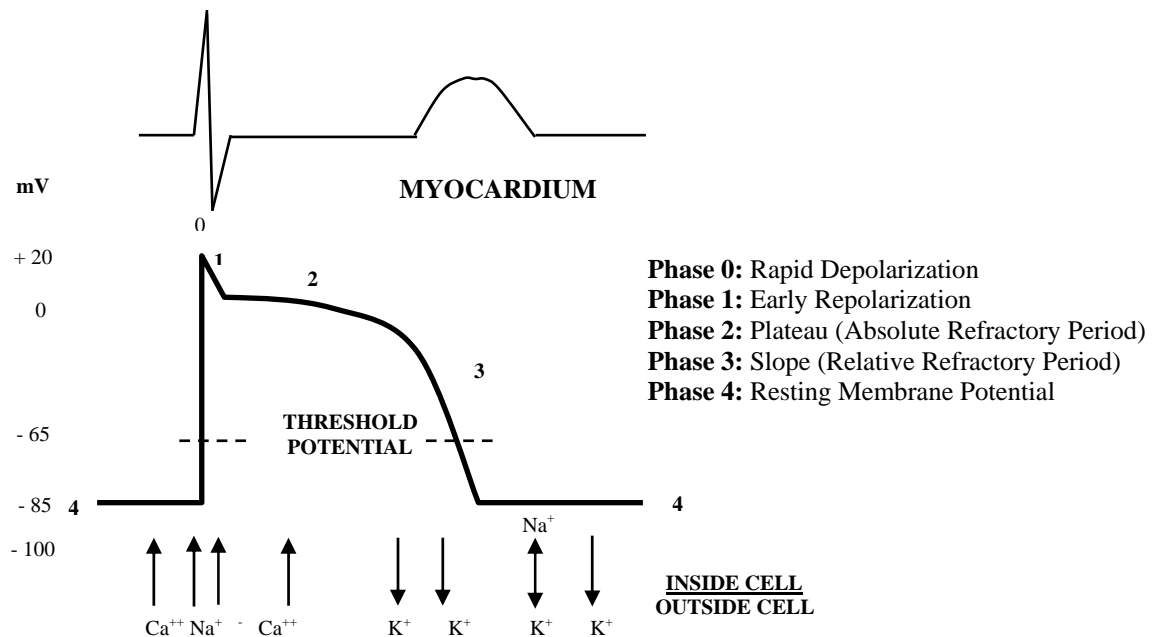


## Section I – Electrophysiology

### Cardiac Conduction System (contd.)

#### Action Potential – Ventricular Muscle

The action potential of ventricular muscle involves the movement of anions and cations across the cell membrane of the cardiac muscle tissue. This movement results in the depolarization and subsequent repolarization of the cell with corresponding contraction of the heart muscle.



**Phase 0:** Rapid Depolarization – cell is stimulated by conducted impulse causing sodium ions to enter the cell through slow channels. When polarity of cell becomes less negative (-65 mV) the fast sodium channels open and the rapid influx of positively charged sodium enters the cell bringing the polarity of the cell to +20 mV.

**Phase 1:** Early Repolarization – Fast sodium channels close. Chloride channels open allowing negatively charged chloride to enter the cell, reducing the positive charge of the cell to neutral (0 mV). There is also a small efflux of potassium at this stage, hence the dip in the action potential.

**Phase 2:** Plateau (Absolute Refractory Period) – calcium channels remain open allowing the influx of positively charged calcium ions to enter the cell. This period is slower allowing for the full depolarization and contraction of the tissue.

**Phase 3:** Slope (Relative Refractory Period) – potassium ions (+ve) leave cell (efflux) reducing the intracellular polarity until it reaches -85 mV again.

**Phase 4:** Resting Membrane Potential – constant efflux of potassium (K<sup>+</sup>) keeps intracellular polarity at -85 mV until next impulse stimulates Phase 0 sodium channel opening.

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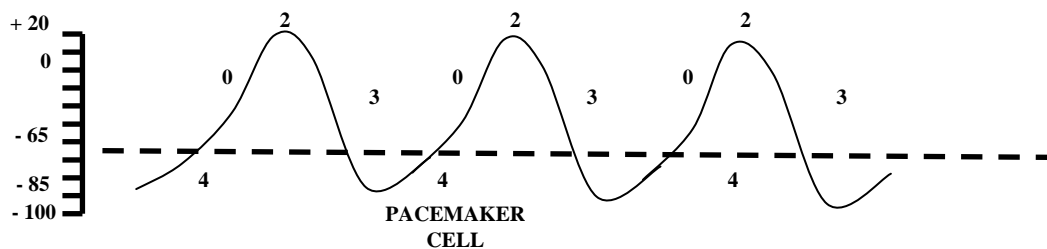


## Section I – Electrophysiology

### 1.0 Cardiac Conduction System (contd.)

#### 1.4 Action Potential – Pacemaker Cell

Automaticity is the heart's ability to generate its own electrical impulses. The SA Node is the primary pacemaker of the heart depolarizing at a rate of 60 to 100 times per minute. Unlike ventricular muscle, the SA Node requires no external stimulation to cause the sodium channels to open. The cell wall membrane of the pacemaker cell is permeable to sodium allowing for the slow influx of this ion from outside to inside the cell. It is also believed that slow calcium channels are present allowing the movement of  $\text{Ca}^{++}$  inside the cell. The movement of the positively charged  $\text{Na}^+$  and  $\text{Ca}^{++}$  ions into the cell results in the slow depolarization of the pacemaker cell.



**Phase 0:** Slow Depolarization

**Phase 1:** Does not Apply

**Phase 2:** Plateau ( Absolute Refractory Period)

**Phase 3:** Relative Refractory Period

**Phase 4:** Spontaneous Phase 4 Rise – constant influx of  $\text{Na}^+$

**Notes:**

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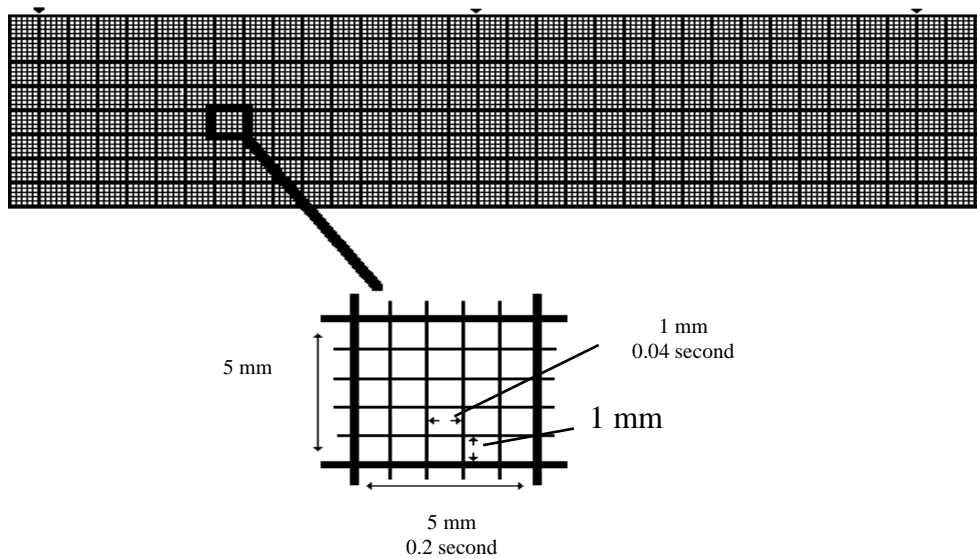




## Section 2.0 – ECG Monitoring Equipment

### ECG Paper

ECG monitors provide both dynamic and static monitoring capabilities. ECG paper has been standardized throughout the industry to maintain a running speed of 25 mm/second. It is the basis of this standard running speed that creates the large boxes with corresponding time frames. The need to know how the math works out is of little importance. The important information to remember is that each small square represents 0.04 second and each large square represents 0.2 second.



Formulas for paper speed and minute interval calculation.

25 mm/sec multiplied by 60 sec = 1500 mm/min

60 (1 minute) seconds divided by 1500 mm = 0.04 sec/mm

0.04 sec/mm x 5 = 0.2 sec/5mm (large square)

1500 mm/min divided by 5 = 300 large squared/min

Notes:

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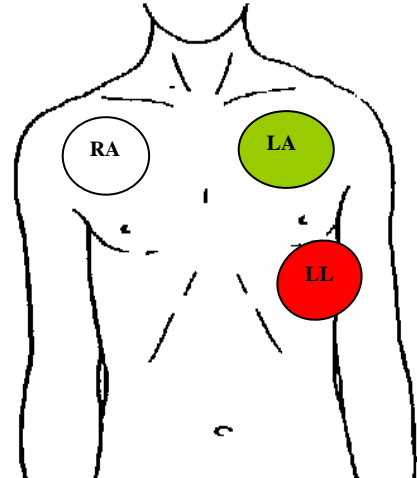
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## Section 2 – ECG Monitoring Equipment

### ECG Cables/Electrodes

ECG cables are colour and letter coded: white (RA), red (LL), black/green (LA). The general rule for lead placement is:

White (**R**ight **A**rm) typically placed over right anterior chest, below clavicle  
Red – (**L**eft **L**eg) placed at mid-axillary line below left nipple line  
Black/Green – (**L**eft **A**rm) placed over left anterior chest, below clavicle  
Ground lead (with 4 lead cable) – generally placed over the right lateral chest

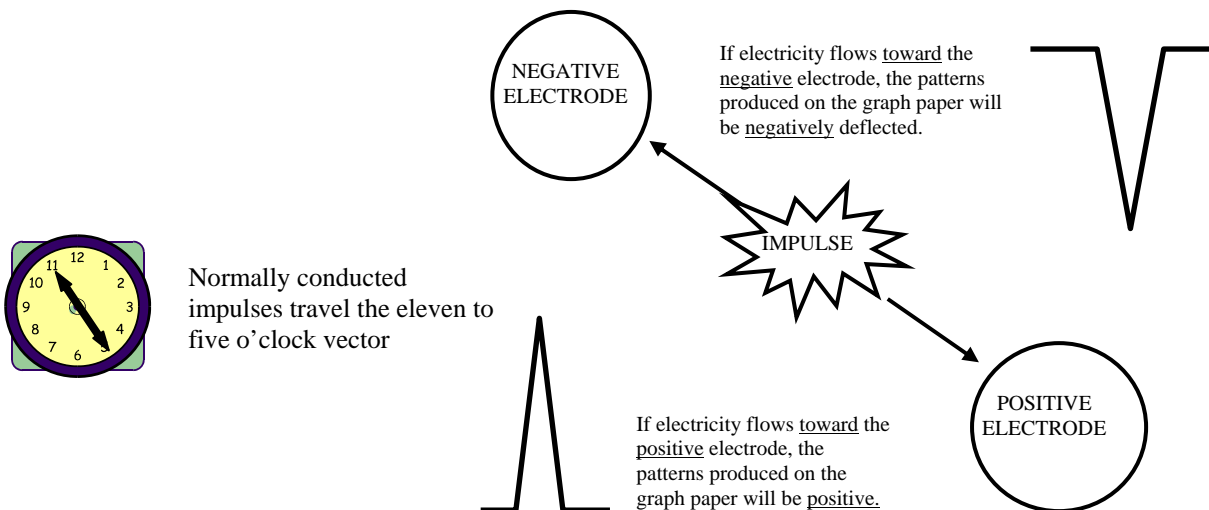


Factors affecting ECG quality:

- ❖ Patient movement
- ❖ ECG electrode directly over large muscle (e.g. bicep)
- ❖ ECG electrode directly over bone
- ❖ dried out electrodes
- ❖ loose connections
- ❖ frayed cables
- ❖ improper lead selection

### Rule of Electrical Flow

ECG complexes are the measurement of electrical flow registered on an oscilloscope (monitor) or plotted on a graph (ECG Paper). The ECG machine measures the electrical current flowing between the negative and positive electrodes. The diagram below describes the rule of electrical flow.



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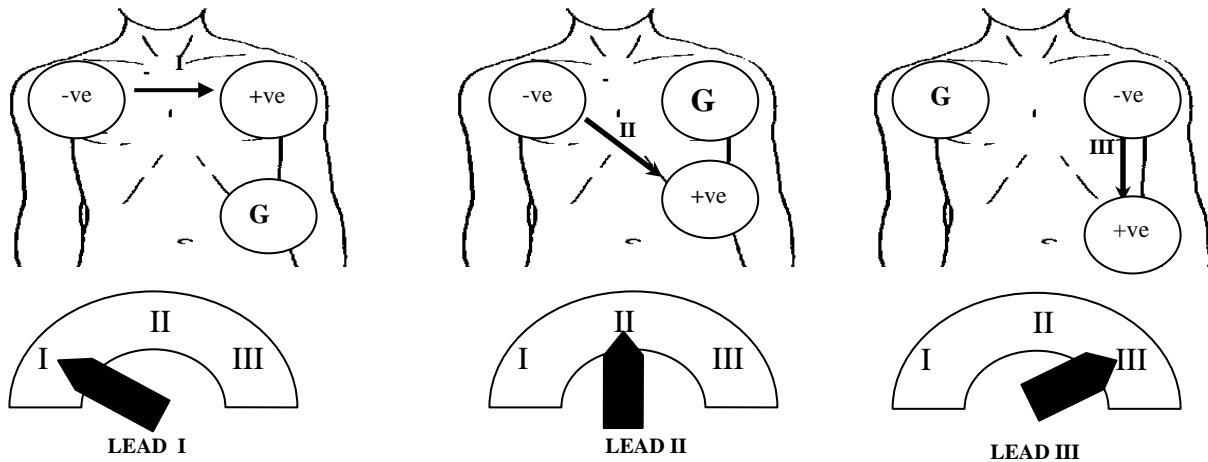
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## Section 2 – ECG Monitoring Equipment

### Lead Placement - Frontal Plane

Most lead II ECG monitoring machines have the ability to look at three different frontal leads. When the lead selection is made by turning the switch to a specific lead, the polarity of the leads changes amongst the white, red and black leads as noted above.



Lead I – monitoring atrial activity when difficult to see in lead II

Lead II – monitoring of normal conduction vector from right atria to left ventricle

Lead III – monitoring horizontal view of the heart with emphasis on left ventricle

### Notes:

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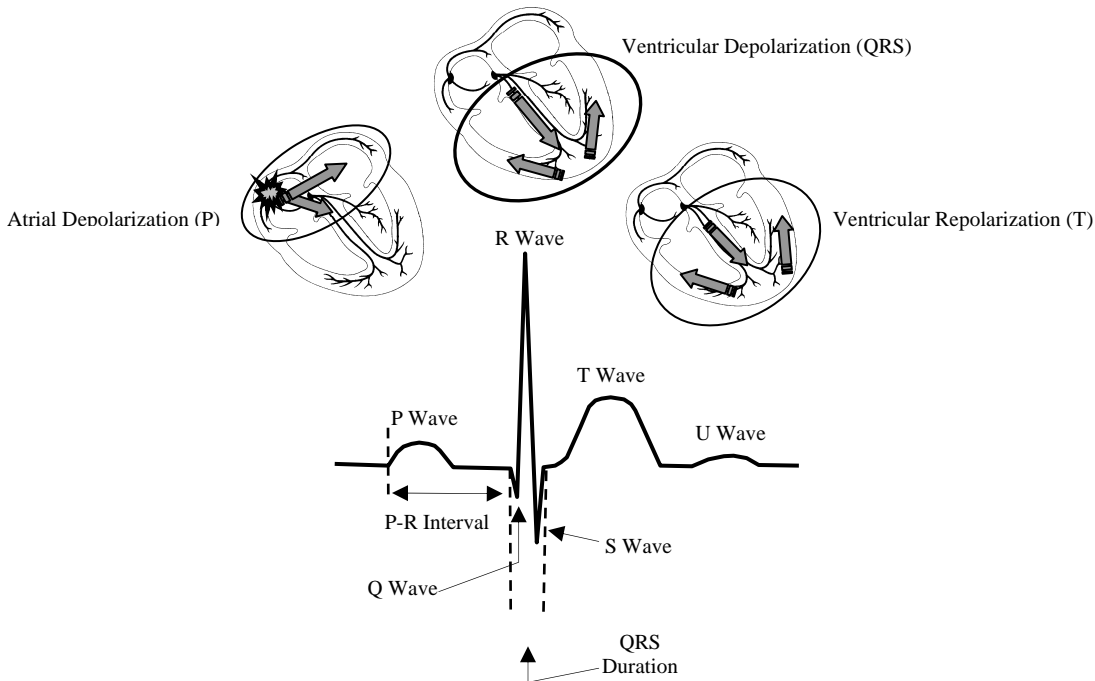
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## Section 3 – ECG Interpretation

### P-QRS-T Configuration

The P-QRS-T configuration of the ECG is the electrical activity representative of the depolarization and repolarization of the atria and ventricles. The following diagram shows the correlation of the components of the ECG and the location within the heart that the electrical activity occurs.



P Wave	<ul style="list-style-type: none"> <li>- depolarization of the atria</li> <li>- usually SA node</li> <li>- upright</li> </ul>
P-R Interval	<ul style="list-style-type: none"> <li>- impulse conduction from SA Node to and through AV node</li> <li>- from beginning of P wave to beginning of QRS complex</li> <li>- delay allows atria to fully contract and expel its content into the ventricles</li> <li>- 0.12 to 0.20 seconds</li> </ul>
QRS Complex	<ul style="list-style-type: none"> <li>- depolarization of the ventricle</li> <li>- 0.08 to 0.10 seconds (or &lt; 0.12)</li> <li>- large amplitude due to large mass of ventricles producing more electrical activity</li> <li>    Q Wave - septal wall depolarization <ul style="list-style-type: none"> <li>- first negative deflection on ECG complex after P wave</li> </ul> </li> <li>    R Wave - ventricular wall depolarization <ul style="list-style-type: none"> <li>- large mass of ventricles</li> <li>- first upright deflection</li> </ul> </li> <li>    S Wave - lateral wall depolarization <ul style="list-style-type: none"> <li>- downward deflection</li> </ul> </li> </ul>
T Wave	- ventricular repolarization
U Wave	- referred to as an “after-depolarization”. May result from electrolyte imbalance (e.g. Hypokalemia) or other causes.

#### Notes:

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### Section 3 – ECG Interpretation

#### QRS Morphology

The QRS complex of the ECG represents ventricular depolarization. The morphology or shape of the QRS complex can vary depending on the lead from which you're viewing the ECG, the individual patient or abnormal pathology. Although the QRS complexes below appear different, they may be "normal" for that individual or be suggestive of an underlying conduction disturbance (especially QRS's  $\geq 0.12$  second).



**qRs**



**qR**



**Rs**



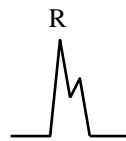
**Q or QS**



**R**



**qRsRs**



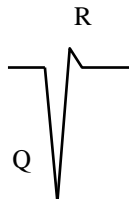
**RsR**



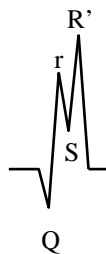
**rS**



**QRS**



**QR**



**qrSR'**



**QrS**

*Notes:*

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### ***Section 3 – ECG Interpretation***

#### **Five Steps For ECG Interpretation**

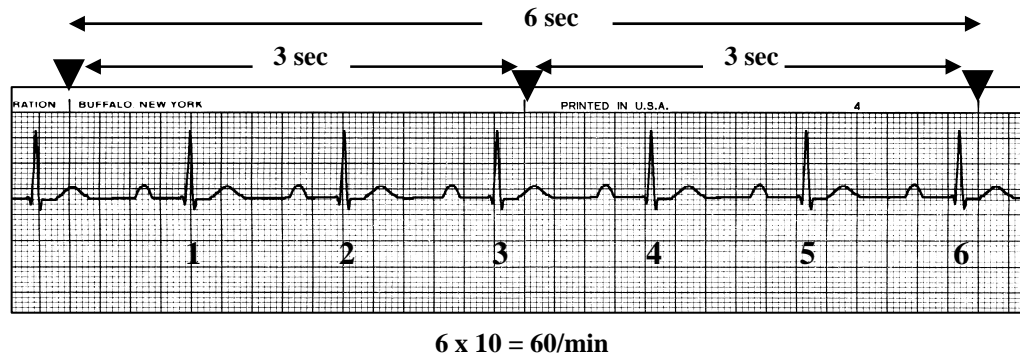
Listed below are the 5 steps to ECG interpretation. When interpreting the ECG it is important to follow the 5 steps to avoid what is known as “Pattern Recognition” whereby the interpreter assumes a rhythm is of one type by just looking at it whereas the rhythm would be identified correctly if the steps were followed.

<b>Step 1 : Rate</b>	< 60	Bradycardic
	60 - 99	Normal
	≥ 100	Tachycardic
<b>Step 2 : Rhythm</b>	Regular	
	Irregular	
<b>Step 3 : P-R Interval</b>	0.12 - 0.20 Second	
<b>Step 4 : P-QRS-T Relation</b>	P Wave For Every QRS-t Complex	
<b>Step 5 : QRS Width</b>	0.08 - 0.10 Second (or < 0.12 second is considered narrow)	
<b>Step 6 : Missing Or Added</b>	Extra Beats Or Missing Beats	

## Step One - Rate

### Method 1

*Count the number of R waves for a six second interval and multiply by ten.*



Points to consider:

- reliable only when rhythm is regular
- good for normal heart rates – accuracy is diminished with fast or slow rates

Notes:

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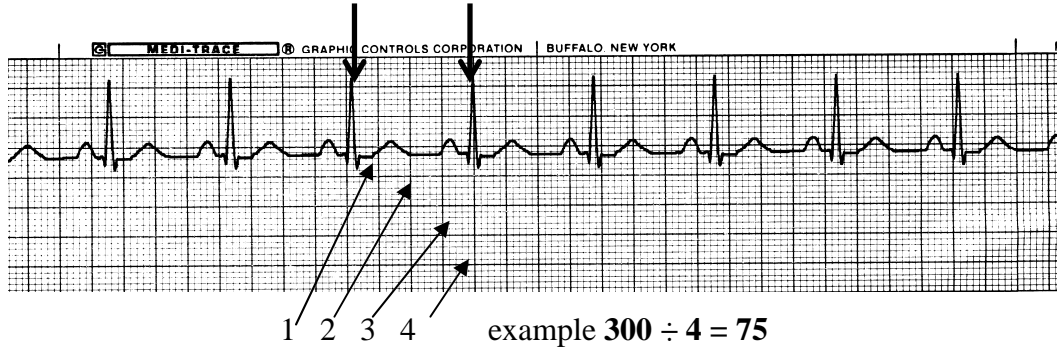
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### Section 3 – ECG Interpretation

Method 2:

*Count the number of 5mm squares between each R wave and divide the number into 300. This will give you the approximate rate/minute.*

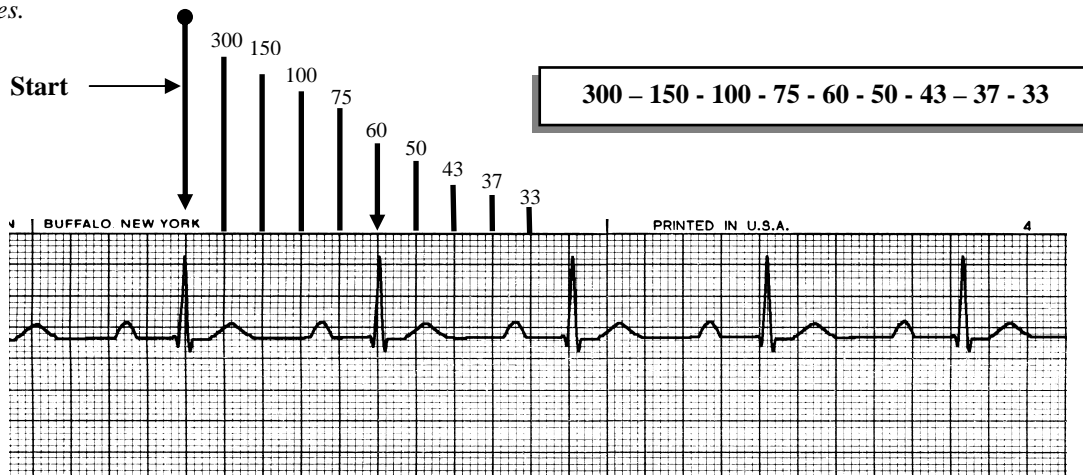


Points to consider:

- must be able to do division in your head

Method 3:

*Using the following scale, where each number represents a 5mm square, count each 5 mm square between two R waves.*



Points to consider:

- memorize the above numbers
- find a QRS complex that falls on a dark line
- count down from the next dark line as shown above
- reliable for regular rhythms
- recommended for brady and tachyarrhythmias

Notes:

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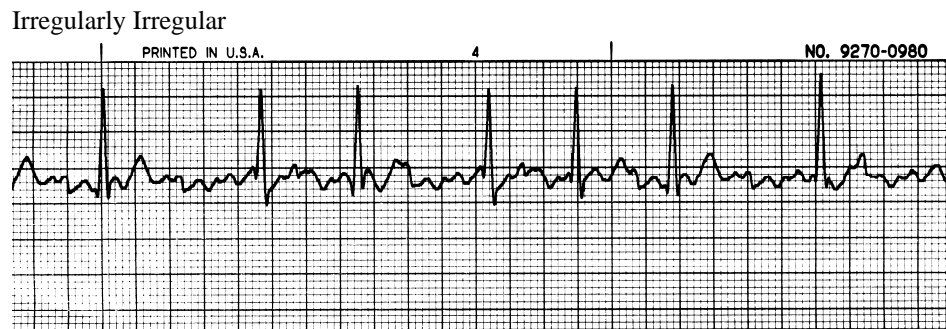
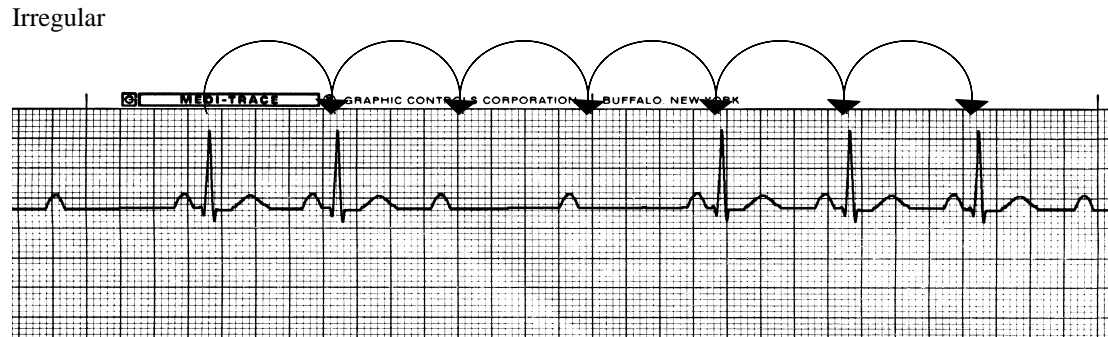
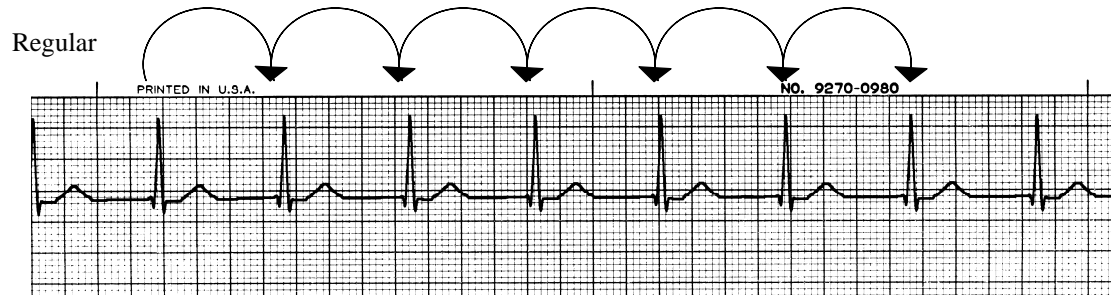


## Section 3 – ECG Interpretation

### Five Steps For ECG Interpretation (cont'd)

#### Step Two - Rhythm

Measure the R to R intervals to determine if the rhythm is regular in nature. It is acceptable to allow for a difference of  $\pm$  one small square when determining regularity of the rhythm



Points to consider:

- regular rhythms are produced by a single focus
- regularly irregular rhythms may occur with heart blocks or regular PVCs
- with very fast rhythms it is sometimes difficult to determine if a regular pattern exists

Notes:

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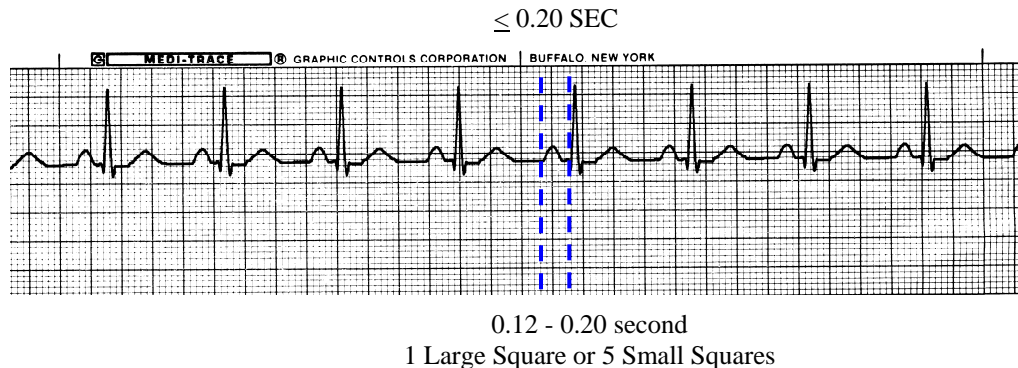
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## Section 3 – ECG Interpretation

### Step Three - P-R Interval

The P-R Interval is the time required for the impulse to travel from the SA node through the AV node. Impulses generated in the atria should take between 0.12 to 0.20 seconds to travel through the AV node. Any delay of > 0.20 seconds is considered a significant conduction delay.

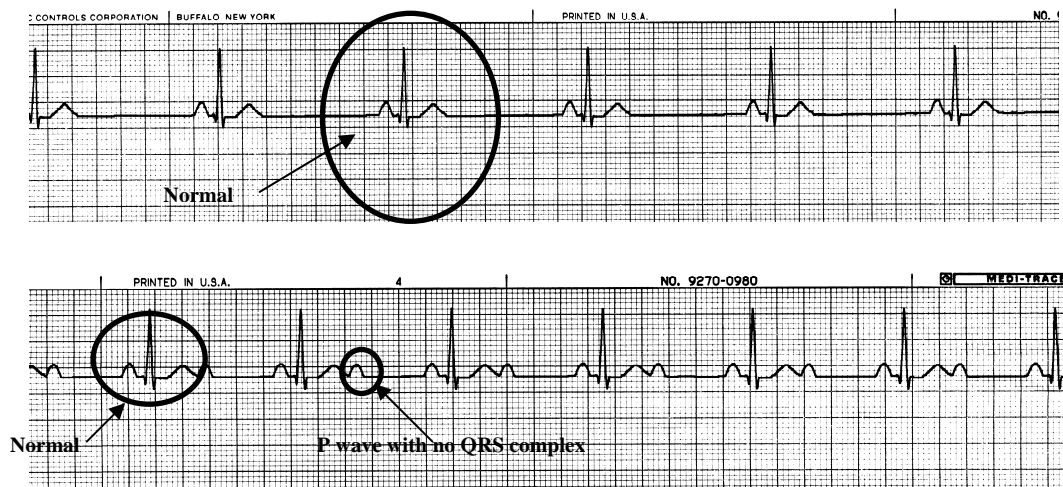


Points to consider:

- measure PR Interval from beginning of P wave to beginning of QRS deflection regardless of morphology
- must identify P wave over T wave

### Step Four - P-QRS-T Relationship

Look for a marriage of P waves to QRS complexes. Normal complexes will always have the components as in the diagram below. P waves with no corresponding QRS complexes or QRS complexes with no associated P wave will signal heart block or ectopic beats.



Points to consider:

- fast rhythms may cause P waves to encroach on the preceding T wave
- more than one P wave per QRS may signal heart block or non-conducted PACs

Notes:

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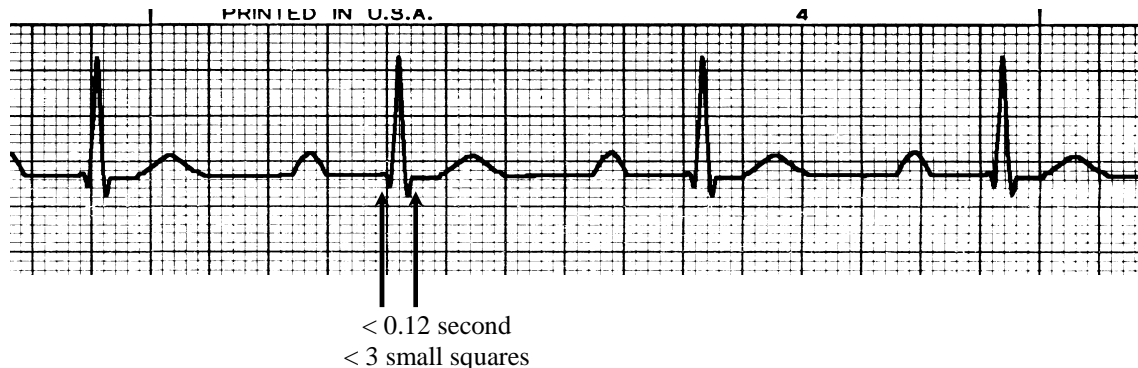


## Section 3 – ECG Interpretation

### Five Steps For ECG Interpretation (cont'd)

#### Step Five - QRS Duration

Measure from the first deflection (+ve or -ve) to where the QRS complex comes back to the isoelectric line (J point). The normal range for the QRS width is  $< 0.12$  second or  $< 3$  small squares.



Points to consider:

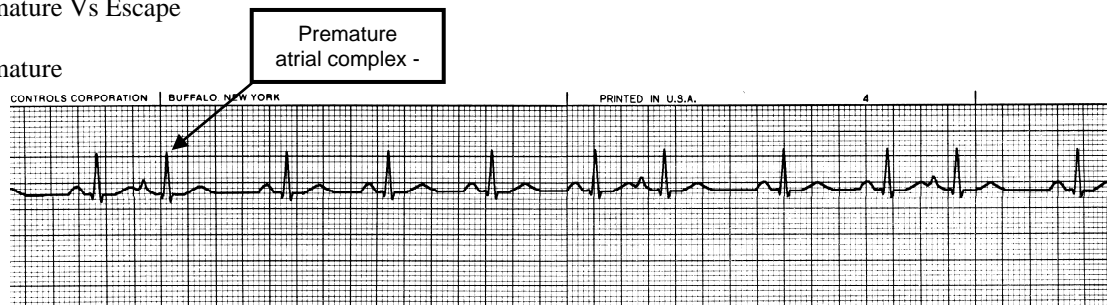
- QRS widths of  $\geq 0.12$  are not always ventricular in origin, but can be supraventricular beats with aberrant conduction as a result of a bundle branch block, drug effect, etc.

#### Step 6 – Anything Missing/Added

This is the unofficial step that can help aid in the interpretation of any ECG. Look for missing beats where you expect them to be, or added complexes where they weren't expected. Look for premature beats or escape beats.

Premature Vs Escape

Premature



Extra QRS complexes which occur before the next expected beat are referred to as premature complexes. There are multiple premature atrial (P waves present) beats in the above strip. Note how they occur prior to the next expected beat.

Notes:

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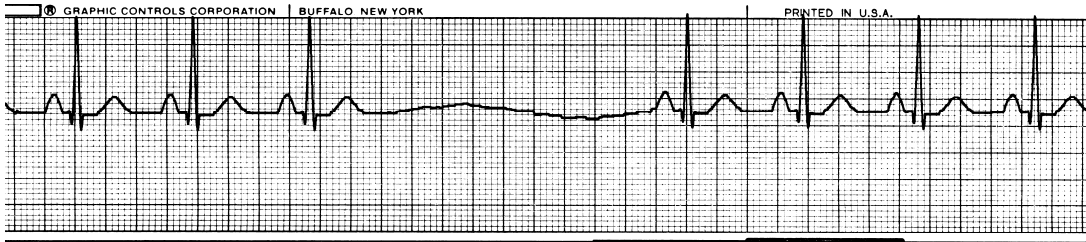
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## Section 3 – ECG Interpretation

### Step 6 – Anything Missing/Added (cont'd)

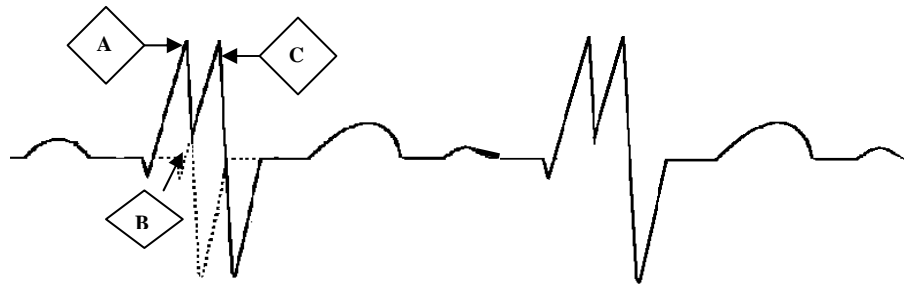
Escape



The above ECG is an example of a **Sinus Arrest**. Note that an *escape beat* (compensatory mechanism) occurs when there is a missing complex. The complex that appears after the delay is referred to as an escape beat.

### 3.3 Aberrant Conduction

Aberrant conduction occurs when the QRS complex appears wider than normal ( $\geq 0.12$  second). The impulse may follow the normal pathways in the atria but as it enters the ventricles it is blocked in either the left or right bundle branches. This results in one ventricle depolarizing just prior to the other ventricle depolarizing. The delay can occur in either the right or the left bundle branch. It is impossible to determine the exact location of the delay using leads I, II or III and requires the use of modified chest leads or a 12 lead ECG to determine the location.



Example:

- A – right ventricle depolarizes
- B – delayed conduction in left bundle branch
- C – left ventricle depolarizes

Notes:

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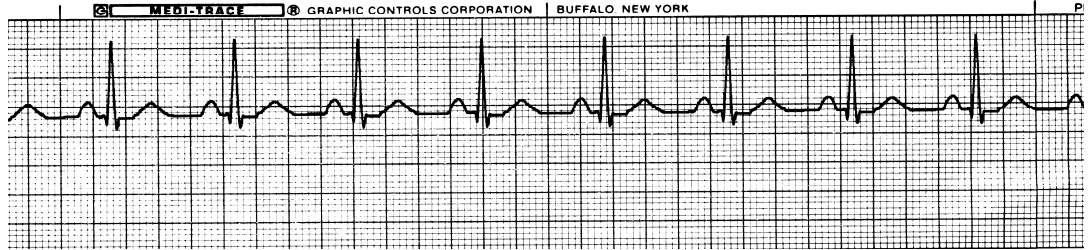
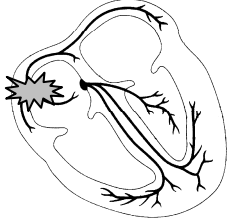




## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supraventricular Rhythms

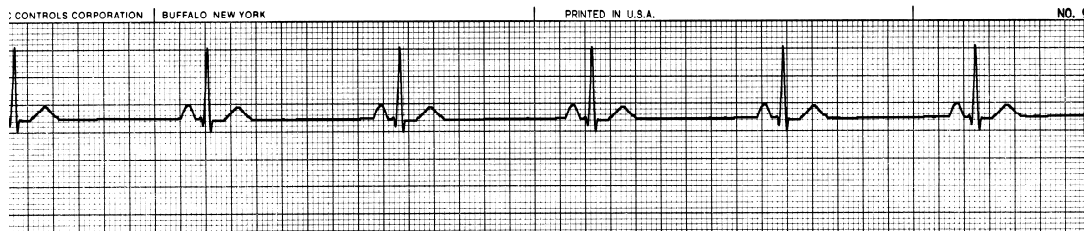
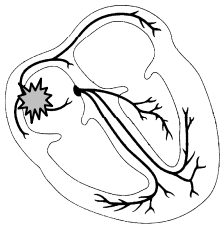
#### Normal Sinus Rhythm (NSR)



Impulses generated by SA Node follow normal conduction pathways.

Rate:	60 - 99
Rhythm:	Regular
P-R Interval :	$\leq 0.20$ second
QRS Width:	$< 0.12$ second
P-QRS-T:	Normal
Missing / Added :	Nothing
Identifying Features:	All criteria normal

#### Sinus Bradycardia



Impulses generated by SA Node follow normal conduction pathways. Rate less than 60 per minute. Benign in nature unless hemodynamically significant. Can be normal in athletes.

Rate :	$< 60$
Rhythm :	Regular
P-R Interval :	$\leq 0.20$ second
QRS Width :	$< 0.12$ second
P-QRS-T :	Yes
Missing / Added :	Nothing
Identifying Features :	Rate less than 60, otherwise normal.

#### Notes:

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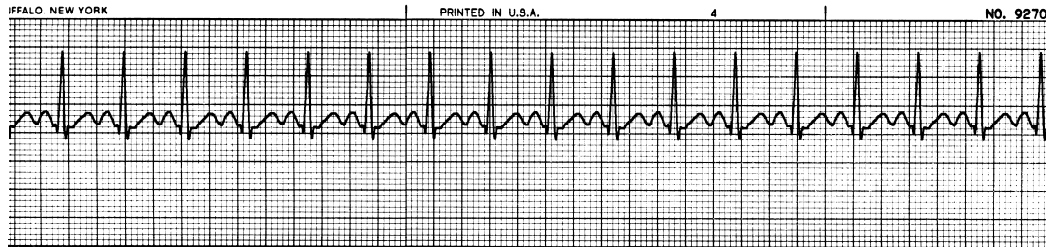
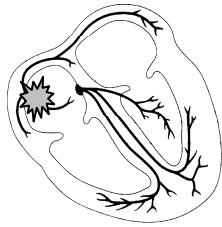
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supraventricular Rhythms

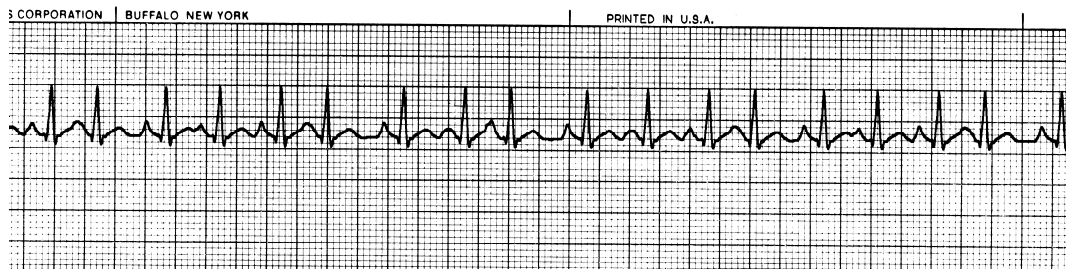
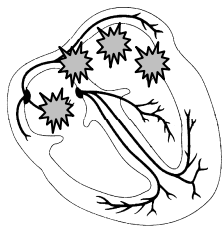
#### Sinus Tachycardia



Impulses generated by SA Node follow normal conduction pathways. Rate is equal or greater than 100 per minute. Usually a sign of hemodynamic compensatory response. Non life threatening unless significant underlying disease process exists.

Rate :	$\geq 100, \leq 160$
Rhythm :	Regular
P-R Interval :	$\leq 0.20$ second
QRS Width :	$< 0.12$ second
P-QRS-T :	Yes
Missing / Added :	Nothing
Identifying Features :	all criteria normal, rate $\geq 100$ and $\leq 160$

#### Multifocal Atrial Tachycardia (MAT)



Impulses generated by multiple sites throughout atria. Rate equal or greater than 100 per minute. Results from atrial irritability. Often confused with atrial fibrillation but has definite P waves with multiple morphologies. An uncommon dysrhythmia, but is seen in COPD and CHF as the result of atrial hypertrophy.

Rate :	$\geq 100$
Rhythm :	Irregularly irregular
P-R Interval :	$\leq 0.20$ second
QRS Width :	$< 0.12$ second
P-QRS-T :	Yes
Missing / Added :	Nothing
Identifying Features :	$\geq 100$ , P waves Present, Irregular

#### Notes:

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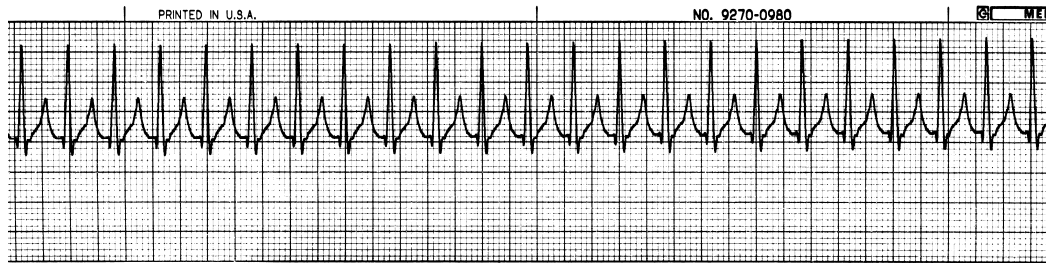
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supraventricular Rhythms

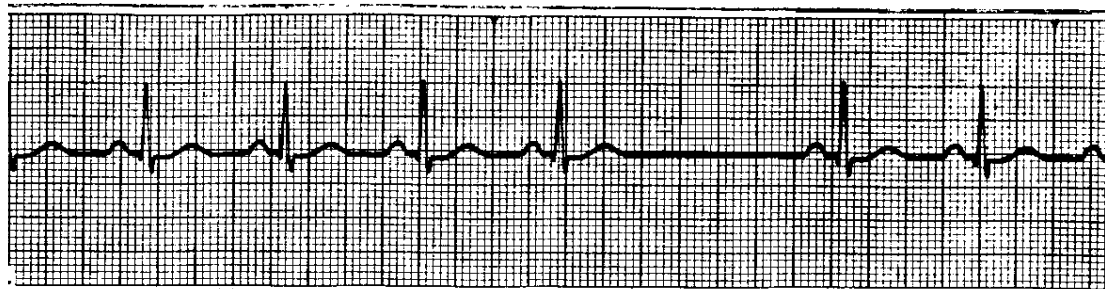
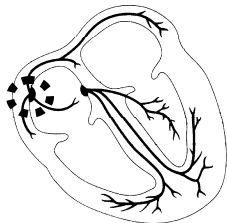
#### Supraventricular Tachycardia (SVT)



Impulses generated from anywhere above the bifurcation of the bundle branches. P waves are absent or not clearly discernable and QRS is generally narrow (unless there's a bundle branch block present). Rate greater than 100 per minute, but generally  $\geq 150$  bpm. Indicative of re-entrant focus or accessory bypass track (e.g. Wolf Parkinson White Syndrome).

Rate :	$\geq 100$ ( $\geq 140$ )
Rhythm :	Regular
P-R Interval	N/A
QRS Width :	$< 0.12$ second (usually)
P-QRS-T :	P waves not clearly visible
Missing / Added :	Nothing
Identifying Features :	reg. narrow complex tachy with no P waves

#### Sinus Exit Block



Sinus Exit Block occurs when the impulse from the SA Node fails to "exit" the surrounding tissue. The SA Node eventually depolarizes when the next expected P wave occurs in the cardiac cycle. There is a non compensatory pause and the SA Node depolarizes in sync with previous P complexes. Can be caused by Sick Sinus Syndrome, hypoxia or electrolyte disturbances.

Rate :	$< 100$
Rhythm :	Irregular
P-R Interval :	$< 0.20$ second
QRS Width :	$< 0.12$ second
P-QRS-T :	Inconsistent
Missing / Added :	Dropped P wave & QRS - Next beat falls into sequence

#### Notes:

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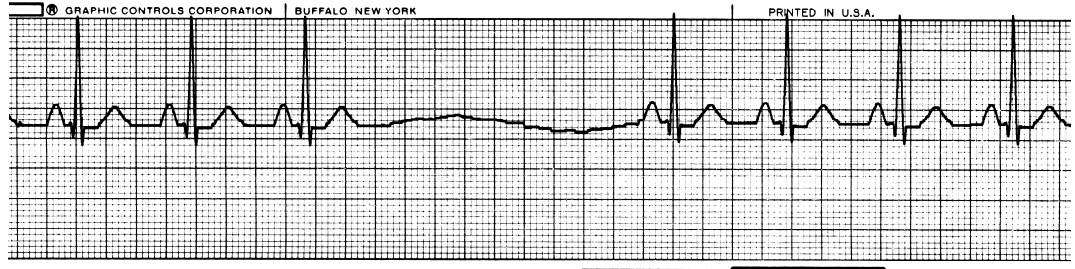
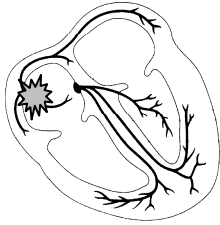
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supraventricular Rhythms (cont'd)

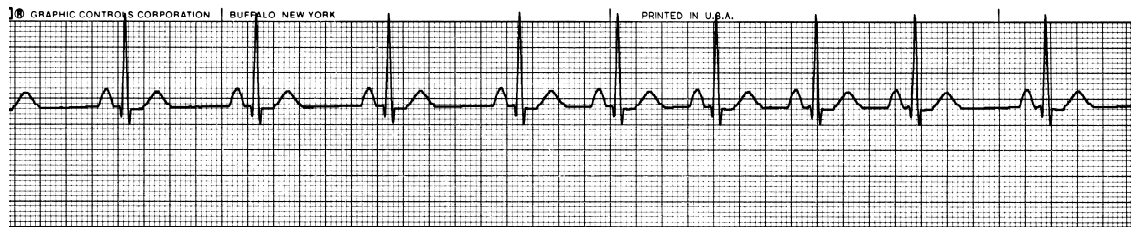
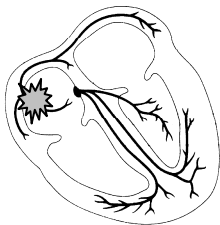
#### Sinus Arrest



Sinus arrest occurs when the SA Node fails to generate impulses. An escape pacemaker generally resumes the function of pacing the heart. Causes include Sick Sinus Syndrome, hypoxia or electrolyte disturbances. *This is a potentially life-threatening dysrhythmia!*

Rate :	< 100
Rhythm :	Irregular
P-R Interval :	< 0.20
QRS Width :	< 0.12 second
P-QRS-T :	Inconsistent
Missing / Added :	Two or more PQRS missing
Identifying Features :	Long pause (flat line). Next beat is an escape pacemaker.

#### Sinus Arrhythmia



Sinus Arrhythmia is seen predominately in the pediatric age group. The ECG shows normal sinus rhythm but the rhythm has an accordion style irregularity that coincides with the patients respiratory pattern. The rhythm speeds up and slows down with ventilation. This is a benign rhythm that is interpreted by watching the patients breathing while simultaneously watching the changes in heart rate.

Rate :	60 - 100
Rhythm :	Irregular
P-R Interval :	$\leq 0.20$ second
QRS Width :	< 0.12 second
P-QRS-T :	Marriage
Missing / Added :	Nothing
Identifying Features :	Slowing of rhythm with respiration

#### Notes:

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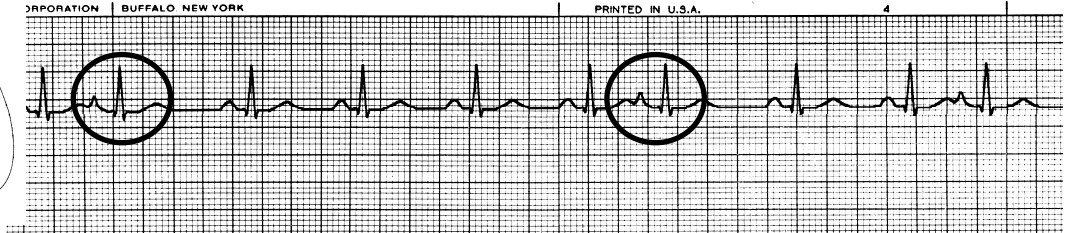
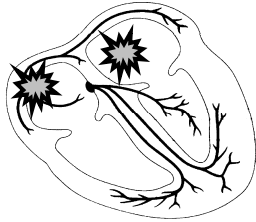




## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supraventricular Rhythms (cont'd)

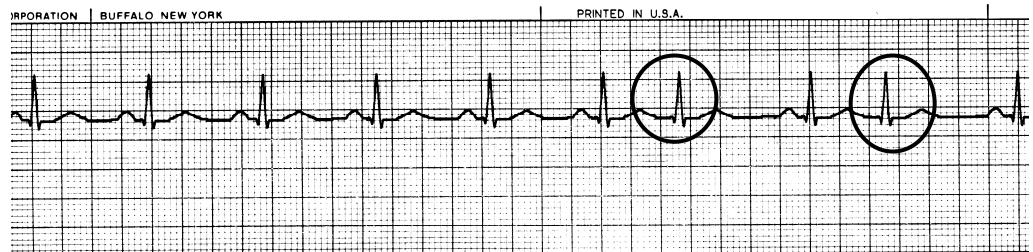
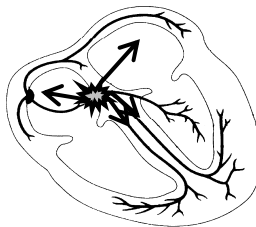
#### Premature Atrial Complex



Premature Atrial Complexes (PAC's) are ectopic beats that occur with an underlying sinus rhythm before the next expected QRS complex. PAC's are distinguished by the presence of a P wave in front of the narrow complex beat. The QRS in a PAC is identical in morphology to the underlying QRS complexes as the conduction follows normal pathways once the impulse passes through the AV node. PAC's are usually benign and often result from atrial hypertrophy or excessive stimulant ingestion (coffee or nicotine) and are indicative of atrial irritability.

Rate :	Can occur with any heart rate
Rhythm :	Irregular
P-R Interval :	$\leq 0.20$ second
QRS Width :	$< 0.12$ second
P-QRS-T :	P waves Present
Missing / Added :	Narrow QRS
Identifying Features :	PAC - narrow complex occurring before next expected QRS complex, P wave present

#### Premature Junctional Complex



Premature Junctional Complexes (PJC's) are ectopic beats that occur with an underlying sinus rhythm before the next expected beat. PJC's are distinguished by the presence of an inverted P wave, the absence of a P wave with a narrow QRS or the presence of an inverted P wave between the QRS and T wave. The QRS is similar in morphology to the underlying QRS as conduction follows the normal pathways in the ventricles. PJC's are usually benign and often caused by stimulants (e.g. coffee or nicotine) and atrial irritability.

Rate :	Can occur with any heart rate
Rhythm :	Irregular
P-R Interval:	$\leq 0.20$ second
QRS Width :	$< 0.12$ seconds
P-QRS-T :	P waves present
Missing / Added :	Narrow QRS with inverted P wave before or after or no P wave visible
Identifying Features :	PJC - Narrow complex occurring before next expected QRS complex

#### Notes:

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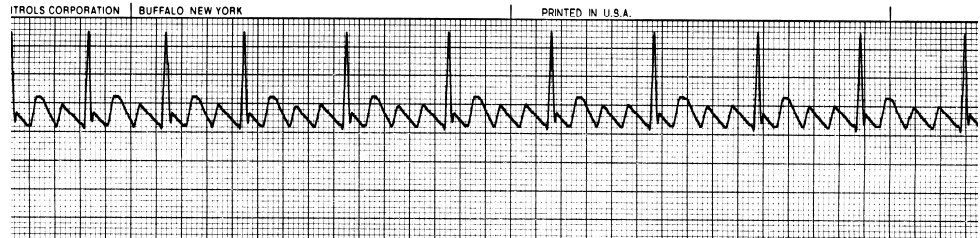
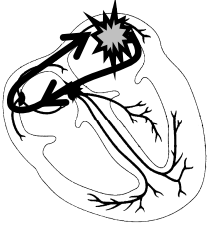
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supraventricular Rhythms (cont'd)

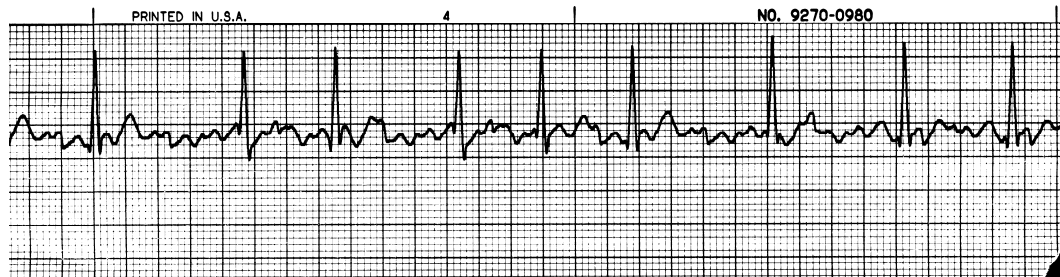
#### Atrial Flutter



Atrial Flutter shows a sawtooth P wave pattern between narrow complex QRS complexes. Seen in COPD or CHF patients resulting from atrial enlargement. The atrial impulses are generated at a rate of approximately 300 per minute but only travel through the AV node at rates of usually 150 or less per minute. The AV node remains in a refractory state allowing only a portion of the impulses to travel through it. Can have a variable conduction pattern of 2:1, 3:1 or 4:1 or any combination as seen in the above strip.

Rate :	May vary
Rhythm :	Regular or irregular
P-R Interval :	$\leq 0.20$ second
QRS Width :	$< 0.12$ second
P-QRS-T :	F waves present
Missing / Added :	Flutter wave between QRS complex
Identifying Features :	Flutter waves replace P waves

#### Atrial Fibrillation



Atrial Fibrillation is an irregularly irregular ECG seen in CHF, AMI, and heart failure patients. The isoelectric line is flat or chaotic in nature with no discernable P waves before the usually narrow QRS complex. Multiple ectopic foci in the atria depolarize at rates exceeding 500 per minute but only a limited number of impulses travel through the AV Node.

Rate :	Variable
Rhythm :	Irregularly irregular
P-R Interval:	N/A
QRS Width :	$< 0.12$ second
P-QRS-T :	No P waves
Missing / Added :	No P waves
Identifying Features :	Irregularly irregular, no discernible P waves, +/- fibrillating baseline

#### Notes:

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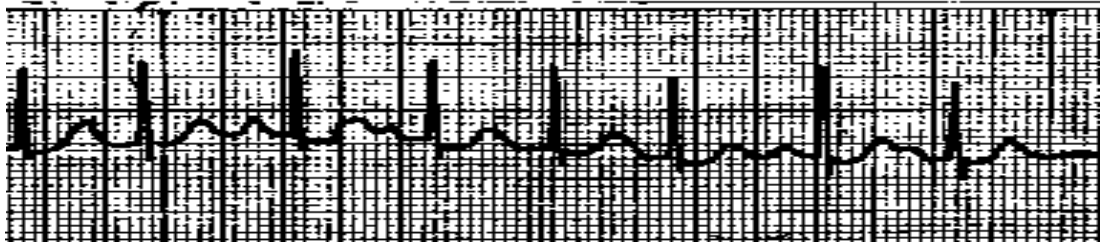
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supraventricular Rhythms (cont'd)

#### Wandering Atrial Pacemaker



Wandering Atrial Pacemaker occurs when there are multiple pacemaker sites in the atria producing an irregular rhythm with P waves of different morphology. Similar to Multi focal Atrial Tachycardia only slower in rate.

Rate :	Variable
Rhythm :	Irregular
P-R Interval :	$\leq 0.20$ second
QRS Width :	$< 0.12$ second
P-QRS-T :	P waves
Missing / Added :	Nothing
Identifying Features :	Different morphology P waves, irregular

#### Notes:

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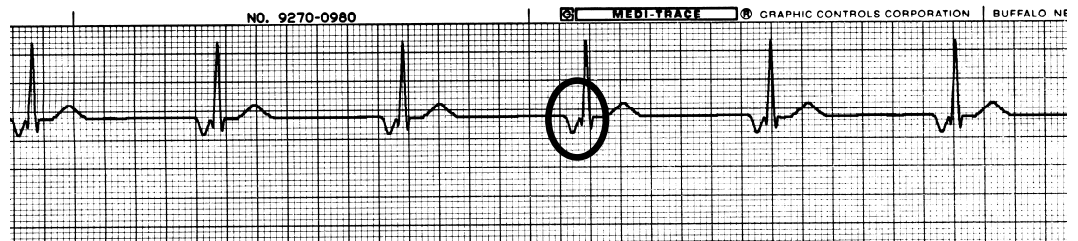
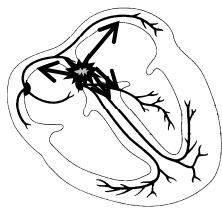
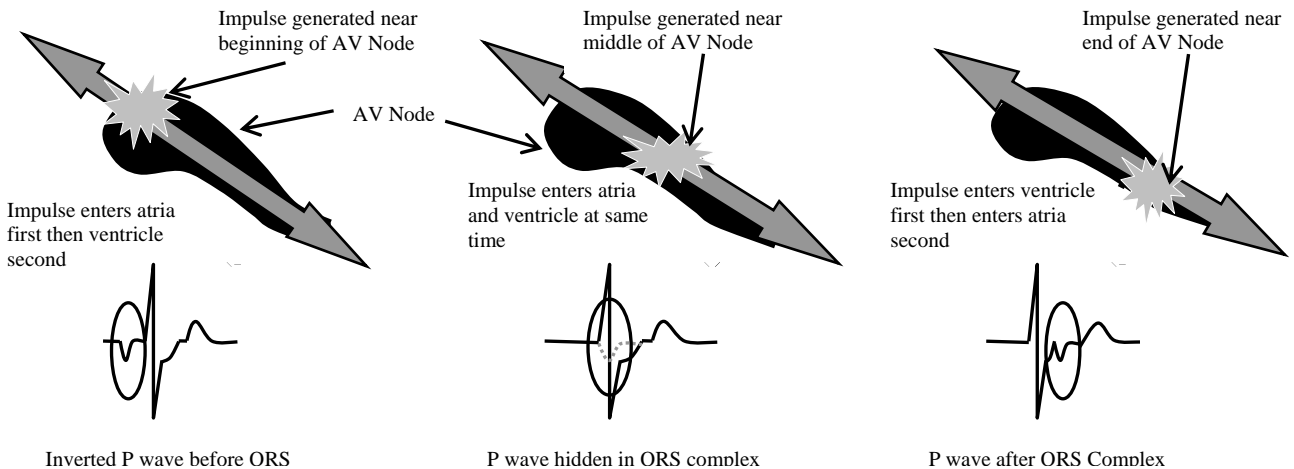
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## Section 4 – Cardiac Rhythms/Arrhythmia's

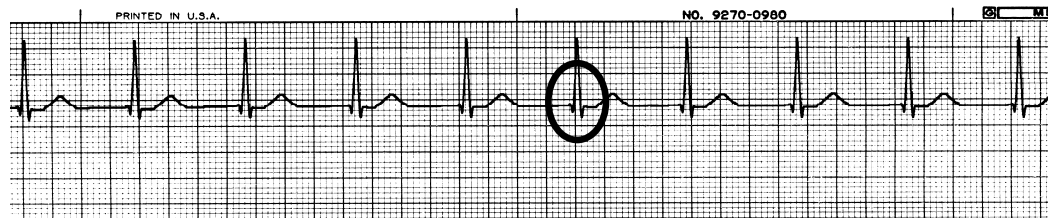
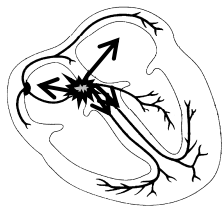
### Supraventricular Rhythms (cont'd)

#### Junctional Rhythm

Junctional Rhythms are generated within the AV Node and are identified by the inverted P waves that occur before, during (hidden from view) or after the QRS complex. The location within the AV Node of impulse generation determines the unique characteristic of the junctional rhythm. The diagram below shows the correlation of the location of the pacemaker and the location of the P wave in conjunction to the QRS complex.



Inverted P wave before QRS complex



No visible P wave – hidden in QRS complex

#### Notes:

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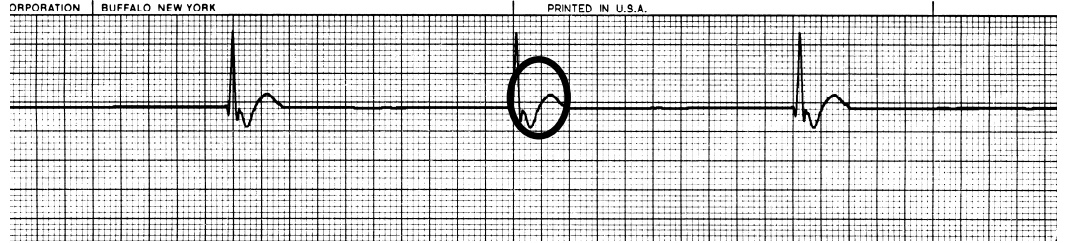
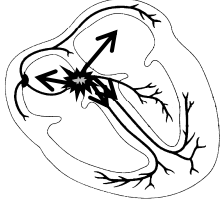
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Supra Ventricular Rhythms (cont'd)

#### Junctional Rhythm (cont'd)



Inverted “retrograde” P wave after QRS complex

Junctional Rhythms are identified by their slow, regular rhythm and narrow QRS complex. Often seen in post cardiac arrest patients and as an escape rhythm in patients with SA Node failure. Inverted P waves are seen before or after the QRS complex. The P waves that occur before the QRS complex will have a shortened P-R interval

Rate:	40 –60
Rhythm :	Regular
P-R Interval :	Narrow if present
QRS Width :	< 0.12 second
P-QRS-T :	Inverted P waves, no P waves
Missing / Added :	retrograde P waves
Identifying Features :	Regular, narrow complex, 40-60, inverted P waves in front, buried, or after QRS complex



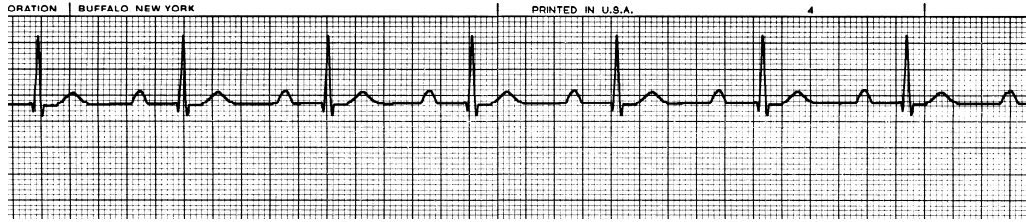
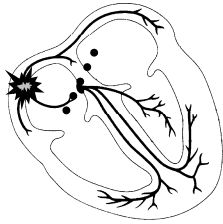
## Section 4 – Cardiac Rhythms/Arrhythmia's

### Heart Blocks

#### Heart Blocks

Heart Blocks can be classified into 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> degree with additional differentiation for 2<sup>nd</sup> degree types. They are indicative of conduction delays through the AV Node or surrounding tissue and can be of little clinical significance or be life-threatening. The life threat increases as the heart block number increases.

#### First Degree Heart Block

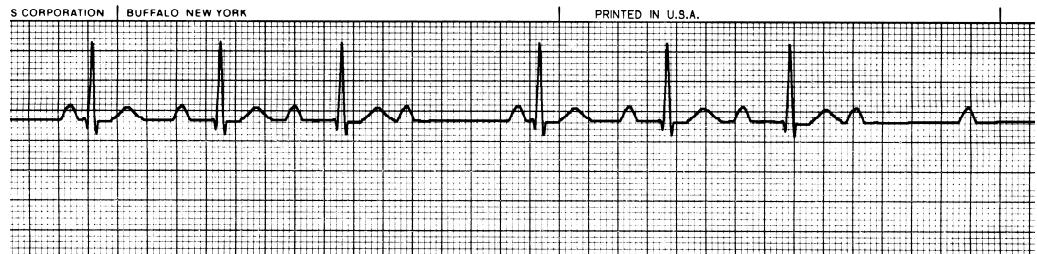
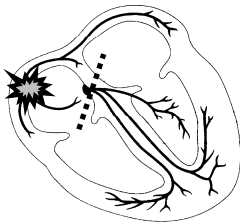


1<sup>st</sup> Degree Heart Block is identified by the prolonged (>0.20 second) P-R interval. Benign in nature and normal in most patients.

Rate :	May vary
Rhythm :	Regular
P-R Interval :	> 0.20 second
QRS Width :	< 0.12 second
P-QRS-T :	Marriage
Missing / Added :	Nothing
Identifying Features :	PR Interval > 0.20 second

#### Notes:

#### Second Degree Heart Block Type I - Wenkebach

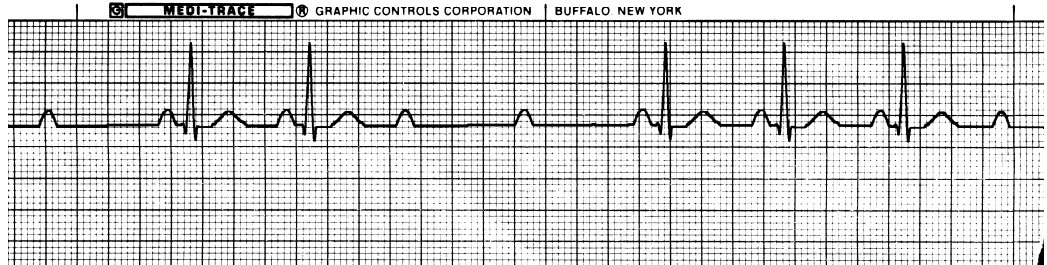
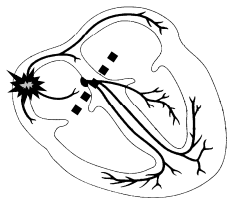


2<sup>nd</sup> Degree Heart Block Type I – Wenkebach is characterized by the gradually increasing P-R interval then a P wave with no associated QRS complex. This pattern then repeats. Block occurs higher in the AV Node. There is no change in the P-P interval as the SA node is unaffected. Seen in patients with increased parasympathetic activity or hypoxia. Usually benign and does not lead to more significant heart blocks.

Rate :	< 100
Rhythm :	Irregular
P-R Interval :	Increases
QRS Width :	< 0.12 second
P-QRS-T :	Inconsistent
Missing / Added :	QRS Complexes dropped
Identifying Features :	PR interval increases until a QRS complex is dropped after a P wave



## Second Degree Heart Block Type II



2<sup>nd</sup> Degree Heart Block Type II is characterized by the constant P-R interval then a P wave with no associated QRS complex. Block occurs further down the AV Node. There is no change in the P-P interval as the SA node is unaffected. Seen in patients with AMI, degenerative nodal disease or hypoxia. May deteriorate to 3<sup>rd</sup> Degree Heart Block.

Rate :	< 60
Rhythm :	Irregular
P-R Interval :	Constant
QRS Width :	< 0.12 second
P-QRS-T :	Inconsistent
Missing / Added :	QRS complexes
Identifying Features :	PR interval constant then a QRS complex is dropped after a P wave

### Notes:

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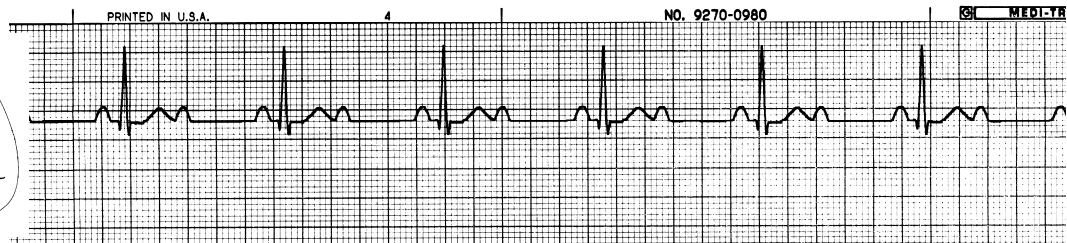
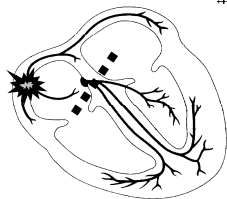


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## Second Degree Heart Block Type II with 2 : 1 conduction



2<sup>nd</sup> Degree Heart Block 2:1 is characterized by the presence of a normal P-QRS-T complex then a P wave with no associated QRS complex. This pattern repeats at a 2:1 ratio (two P waves for every one QRS complex). Seen in patients with AMI, degenerative nodal disease or hypoxia. May deteriorate to more significant heart blocks specifically 3<sup>rd</sup> Degree Heart Block.

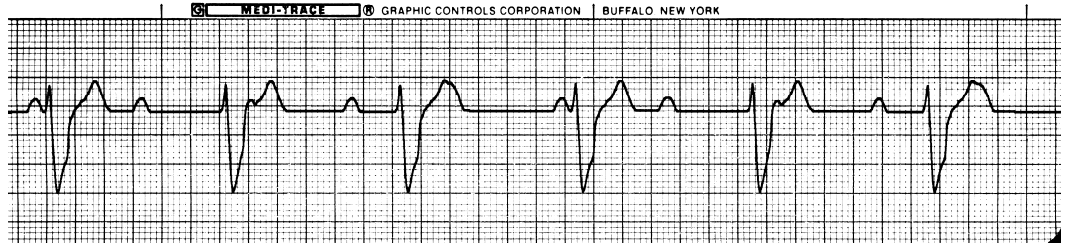
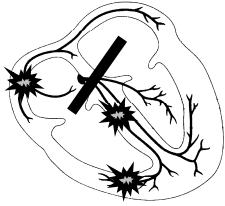
Rate:	< 60 Bradycardic
Rhythm:	Regular
P-R Interval:	Constant
QRS Width:	< 0.12 second
P-QRS-T:	Inconsistent
Missing / Added:	QRS Complexes
Identifying Features:	PR interval constant then a QRS complex is dropped after a P wave



## Section 4 – Cardiac Rhythms/Arrhythmia's

### Heart Blocks (cont'd)

#### Third Degree Heart Block



3<sup>rd</sup> Degree Heart Block is a bradycardic rhythm characterized by a regular, wide QRS complex. P waves are present but have no relationship with the QRS complexes. The P waves appear to march through the QRS complexes. The blockage between the atria and ventricles is complete preventing the SA Node generated impulses to pass through to the ventricles. The wide QRS complex rhythm is generated in the ventricle as an escape rhythm. Seen in patients with AMI, degenerative nodal disease and hypoxia.

Rate :	< 60 bradycardic
Rhythm :	Regular
P-R Interval :	Varies
QRS Width :	$\geq 0.12$ second
P-QRS-T :	No marriage
Missing / Added :	Nothing
Identifying Features :	P waves march through QRS complex, no marriage between P waves and QRS complexes, regular ventricular response

#### Notes:

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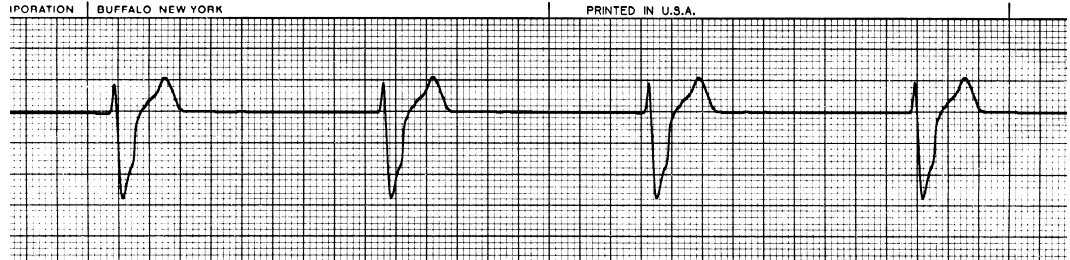
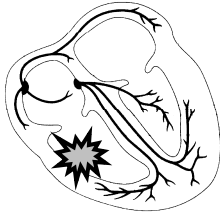




## Section 4 – Cardiac Rhythms/Arrhythmia's

### Ventricular Rhythms Con't

#### Idioventricular



Idioventricular Rhythm is an escape rhythm that is generated somewhere within the ventricle and at a bradycardic rate. The pacemaker depolarizes at a regular rate between 20 to 40 per minute. Wide complex in nature. Seen in AMI, post arrest patients, other pathologies. Patients generally present with severe hemodynamic compromise.

Rate :	20 – 40
P-R Interval :	No P waves
Rhythm :	Regular
P-QRS-T :	N/A
QRS Width :	$\geq 0.12$ second
Missing / Added :	P waves
Identifying Features :	Wide and slow - P's absent

#### Notes:

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## Section 4 – Cardiac Rhythms/Arrhythmia's

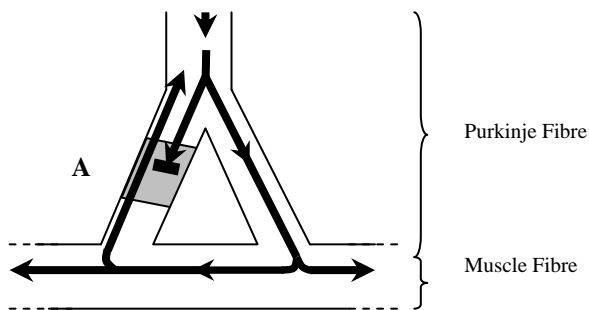
### Ventricular Rhythms (cont'd)

#### Premature Ventricular Complexes (PVC)

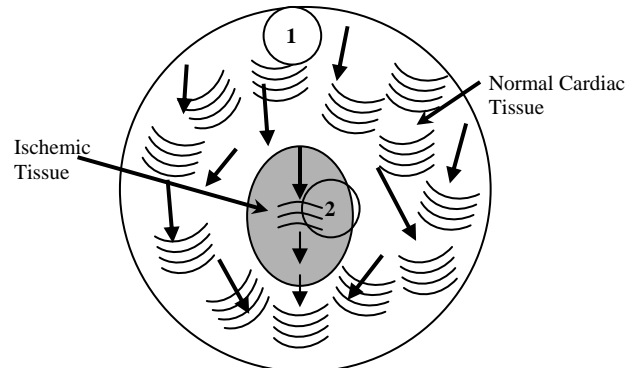
Premature Ventricular Complexes (PVCs) are ectopic complexes that accompany a supraventricular rhythm such as normal sinus rhythm. The PVCs are wide complex ( $\geq 0.12$  second) and can look similar or be of different morphology. PVC's occur before the next expected beat.

#### Etiology of a PVC: Re-entry

Example "A" displayed below shows the re-entry of an impulse through the Purkinje fibre. Antegrade conduction is stopped as it flows through ischemic or hypoxic tissue (A). Retrograde conduction flows through the tissue and stimulates a depolarization as it escapes the damaged tissue. Example "B" shows normal antegrade conduction as it flows through cardiac tissue (1) followed by the impulse slowing down through ischemic tissue (2). When the impulse breaks out of the ischemic zone, the surrounding tissue which was stimulated by the wave of electrical activity to depolarize, has reached the relative refractory period of repolarization and is ready to accept another impulse. This results in the depolarization of the tissue and a PVC is generated.



Example A



Example B

#### Notes:

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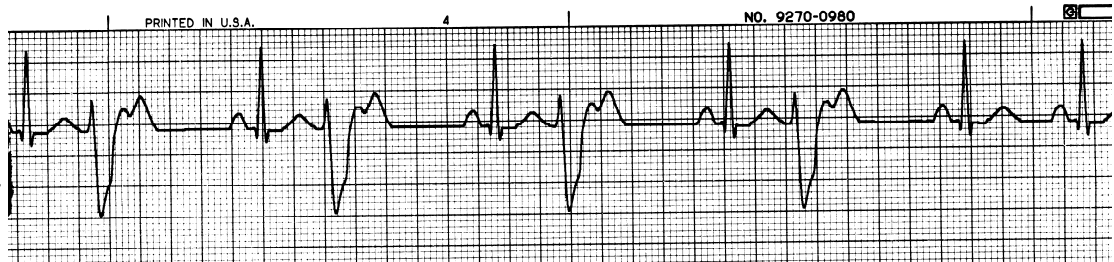
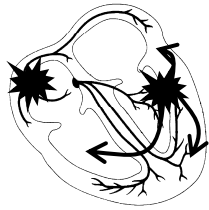


## Section 4 – Cardiac Rhythms/Arrhythmia's

### Ventricular Rhythms (cont'd)

#### Premature Ventricular Contraction (cont'd)

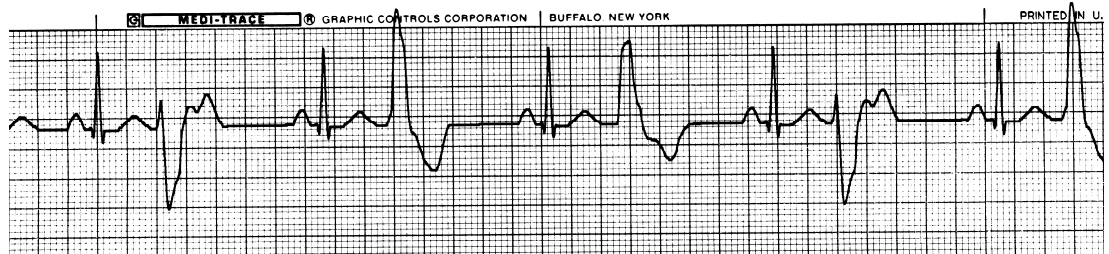
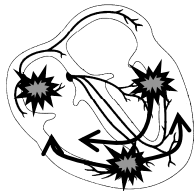
##### Unifocal



Unifocal PVC's are the result of a single ectopic foci originating in the ventricle. The presence of PVCs was once thought to be of clinical significance however recent clinical practice has placed PVCs as a low treatment priority unless there is significant hemodynamic compromise or the patient is experiencing severe chest pain. Unifocal PVCs are similar in nature. Caused by hypoxia, MI, electrolyte imbalances.

Rate :	60 - 160
Rhythm :	Irregular
P-R Interval :	< 0.20 seconds
QRS Width :	normal and > 0.12 seconds
P-QRS-T :	Inconsistent
Missing /Added :	Wide QRS complexes
Identifying Features :	Wide QRS complexes without P waves occurring before next expected QRS interval, similar in morphology

##### Multifocal



Multi Focal PVC's are the result of multiple ectopic foci originating in different locations within the ventricle. Multifocal PVCs are different in morphology. Multifocal PVCs are significant of more severe disease process in the setting of hypoxia, AMI and ischemia.

Rate :	60 - 160
Rhythm :	Irregular
P-R Interval :	< 0.20 seconds
QRS Width :	> 0.12 seconds
P-QRS-T :	Inconsistent
Missing / Added :	Wide QRS complexes
Identifying Features :	Wide QRS complexes without P waves occurring before next expected QRS interval, different in morphology

##### Notes:

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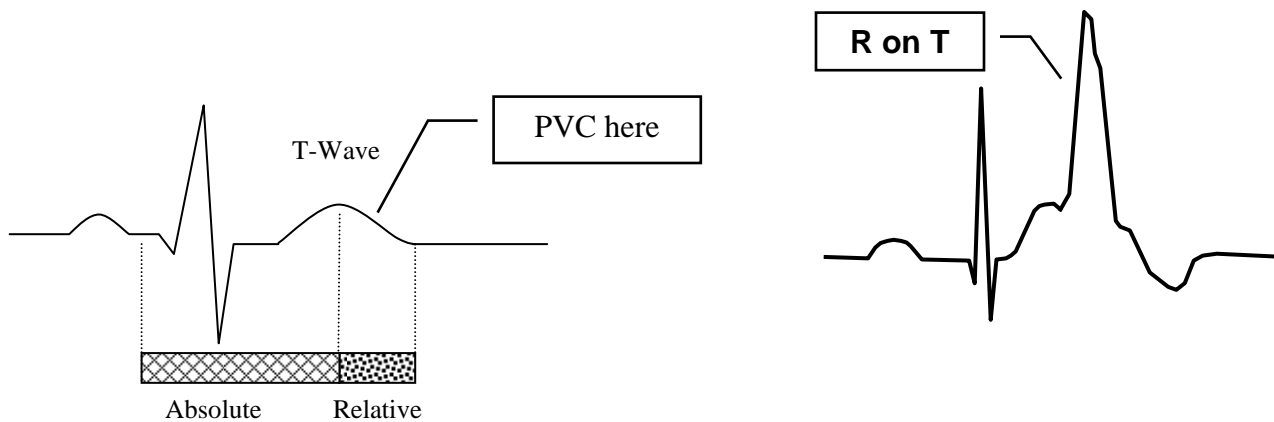


## Section 4 – Cardiac Rhythms/Arrhythmia's

### Ventricular Rhythms (cont'd)

#### **R on T** PVC

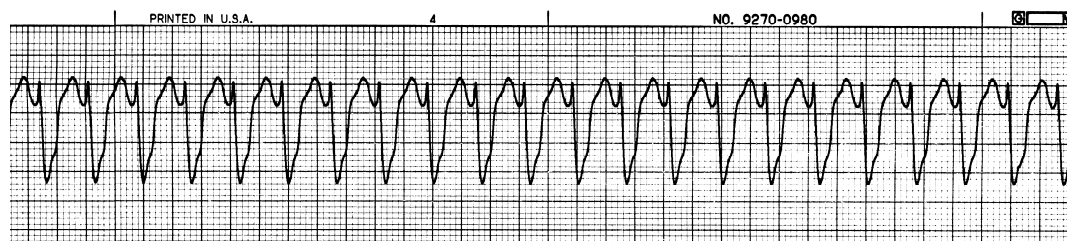
R on T occurs when PVC falls on the relative refractory period of the cardiac cycle. This period is the last half of the repolarization phase of the T-Wave. If a strong enough electrical signal stimulates the cardiac tissue during the relative refractory period, the tissue will depolarize and produce a QRS complex.



## Section 4 – Cardiac Rhythms/Arrhythmia's

## Ventricular Rhythms (cont'd)

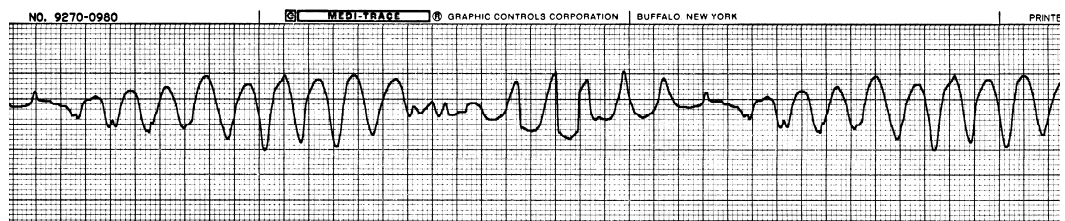
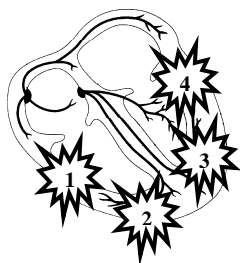
### Ventricular Tachycardia



Ventricular Tachycardia (VT) is characterized by a wide complex, rapid rate that is regular in nature. There is a saw tooth pattern created by the opposite deflection of the T wave to the QRS complex. May spontaneously convert to NSR or may deteriorate to Ventricular Fibrillation unless corrected by chemical or electrical cardioversion. Caused by hypoxia, MI, electrolyte imbalances, electrical shock, etc.

Rate :	>100 (generally > 120)
QRS Width:	$\geq 0.12$ seconds
Rhythm:	Regular
P-QRS-T:	No P waves
P-R Interval:	None
Missing / Added:	P waves missing
Identifying Features:	Regular wide QRS complex rhythm without P waves at rates of $\geq 100/\text{min}$

### Torsades de Pointes (Polymorphic Ventricular Tachycardia)



*Torsades de Pointe* (Polymorphic Ventricular Tachycardia) is characterized by a wide saw tooth pattern that rotates on the graph paper. This results from different sites in the ventricle depolarizing in a systematic manner as shown in the diagram above. May be caused by hypomagnesaemia, prolonged Q-T or drug effect.

Rate :	$\geq 100$
QRS Width:	$\geq 0.12$ second
Rhythm:	Irregular
P-QRS-T:	No P waves
P-R Interval:	None
Missing / Added:	P waves Missing
Identifying Features:	Wide QRS complex rhythm that appears to twist

#### Notes:

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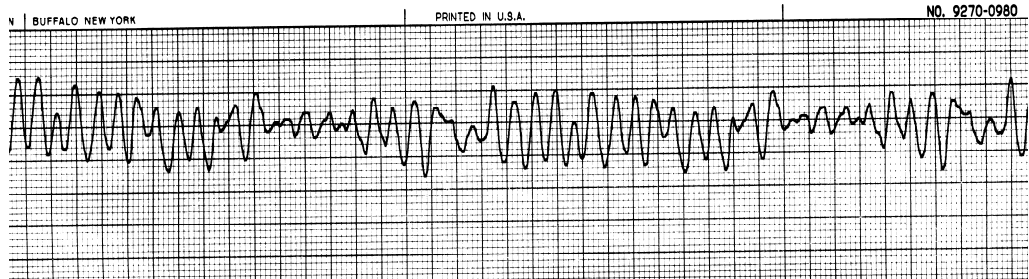
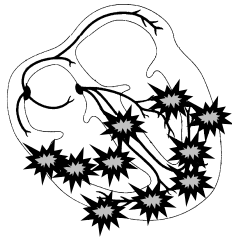
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Ventricular Rhythms (cont'd)

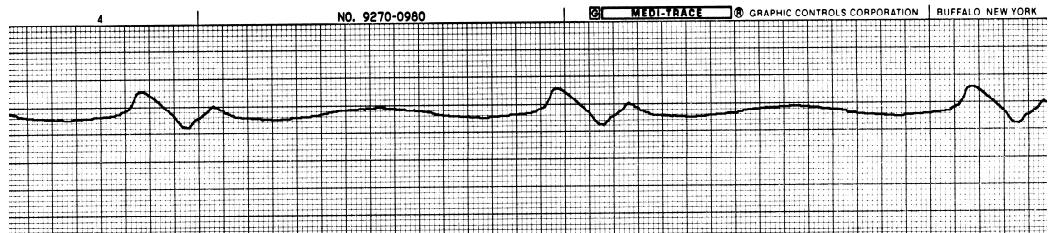
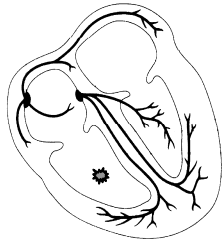
#### Ventricular Fibrillation - Coarse



Ventricular Fibrillation (VF) presents with chaotic electrical activity as the result of multiple ectopic foci originating in the ventricles. There are no organized QRS complexes. This lethal rhythm is seen in approximately seventy percent of sudden cardiac arrests. Fine and Coarse VF are differentiated by the amplitude of the activity. Fine VF has an amplitude of less than 5 mm (1 large square) whereas coarse VF is greater than 5 mm in amplitude.

Rate :	N/A
Rhythm:	Irregular
P-R Interval:	None
QRS Width:	N/A
P-QRS-T:	No P waves, no QRS or T
Missing / Added:	No normal complexes
Identifying Features:	Wide, chaotic electrical activity greater than 1 large square in height

#### Agonal Rhythm



Agonal Rhythm is a low amplitude, wide complex rhythm that has long periods of asystole. Treated like asystole, this rhythm is seen as a terminal event in cardiac arrest patients.

Rate :	< 20
Rhythm:	Regular or irregular
P-R Interval:	N/A
QRS Width:	> 0.12 sec.(usually > 0.20)
P-QRS-T:	No P waves
Missing / Added:	Normal QRS
Identifying Features:	Slow, with long periods of flatline

#### Notes:

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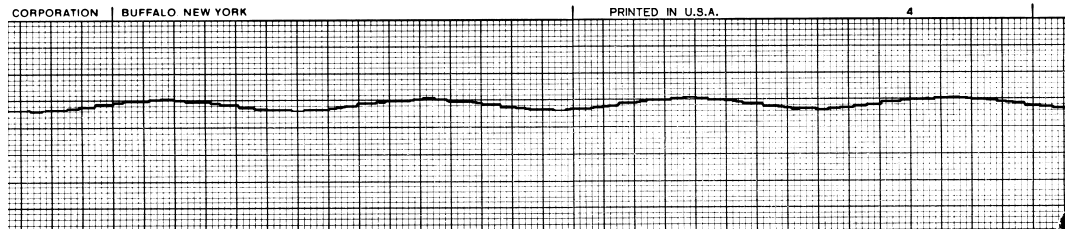
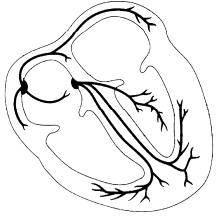




## Section 4 – Cardiac Rhythms/Arrhythmia's

### Ventricular Rhythms (cont'd)

#### Asystole



Asystole is a flat line indicative of no electrical activity occurring anywhere in the heart. The baseline will undulate in a wavelike pattern or remain completely flat. Terminal event that has little chance of correction in most cases

Rate :	0
Rhythm:	None
P-R Interval:	None
QRS Width:	0
P-QRS-T:	No P-QRS-T
Missing / Added:	Normal QRS
Identifying Features:	Flatline

#### Notes:

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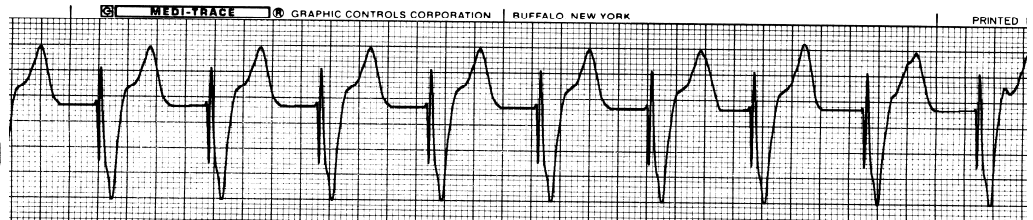
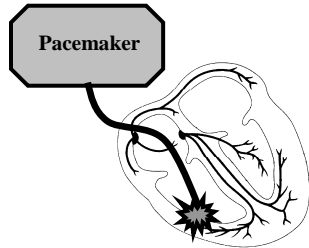
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## Section 4 – Cardiac Rhythms/Arrhythmia's

### Pacemaker Rhythms

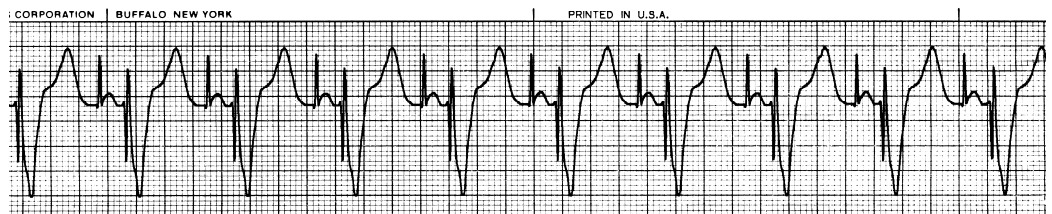
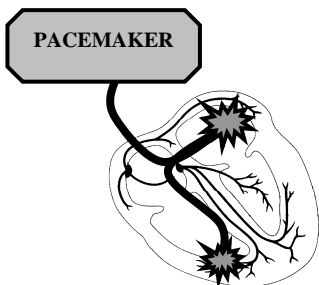
#### Ventricular Pacemaker



Ventricular Paced Rhythm is identified by a pacer spike; a narrow vertical line that precedes a wide QRS complex. The pacemaker electrode is embedded in the right ventricle and when stimulated produces the wide QRS. Seen in patients with history of implanted defibrillator, heart block, sick sinus syndrome and bradycardia.

Rate :	60 - 100
Rhythm:	Regular
P-R Interval:	None
QRS Width:	$\geq 0.12$ seconds
P-QRS-T:	No P
Missing / Added:	Pacemaker spikes
Identifying Features:	Regular, wide complex with pacer spike before the complex

#### AV Sequential Pacemaker



Atrio-Ventricular Sequential Pacemaker is identified by two pacemaker spikes followed by 1) a normal P wave and 2) a wide QRS complex. Seen in patients with history of implanted defibrillator, heart block, sick sinus syndrome and bradycardia. Patients with this type of pacemaker have the benefit of atrial contraction or "atrial kick" to aid in cardiac output. Not all pacemaker candidates qualify for a dual chamber pacemaker.

Rate :	60 - 100
Rhythm:	Regular
P-R Interval:	None
QRS Width:	$\geq 0.12$ seconds
P-QRS-T:	Paced P, paced QRS
Missing / Added:	Pacemaker spikes in front of P waves and QRS complexes
Identifying Features:	Regular, wide complex with pacer spike before both P wave and QRS

#### Notes:

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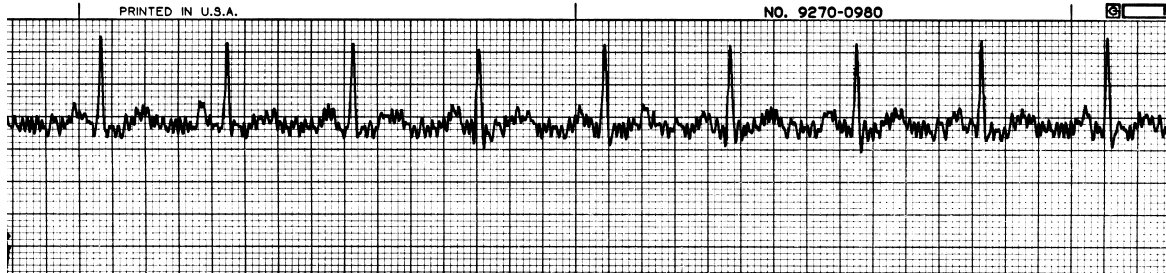


## Section 4 – Cardiac Rhythms/Arrhythmia's

### Artifact

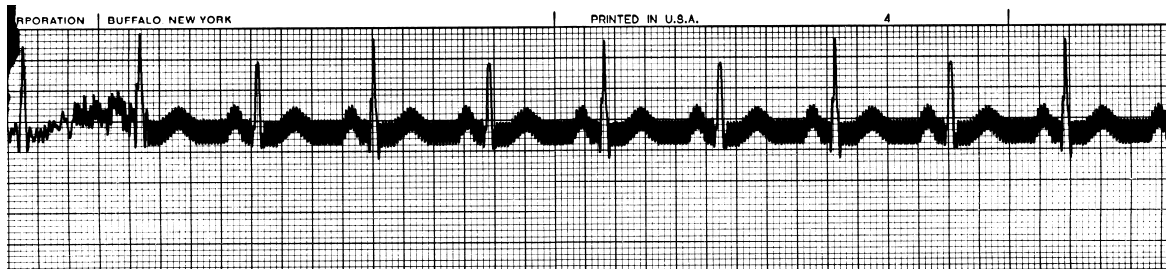
#### Baseline Artifact

Baseline artifact is seen on the ECG when there are problems with the recording of the electrical activity. The artifact on the strip below distorts the baseline and can make P wave identification impossible. This results from poor electrode contact, dried out electrodes, patient movement, damaged cables and improper electrode placement such as over a bony area or large muscle mass.



#### 60 Cycle Interference

60 Cycle Interference is seen when the patient is in close proximity to an electrical supply outlet or when electrical appliances are operating in close proximity to the ECG machine. When encountering 60 Cycle Interference the operator needs only to turn off the electrical appliance to eliminate the interference.



[illegible]