

# **INTRODUCTORY GUIDE TO IDENTIFYING**

## **ECG IRREGULARITIES**

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**NOTICE:** This is an introductory guide for a user to understand basic ECG tracings and parameters. The guide will allow user to identify some of the differences between regular and irregular ECG tracings based on **Lead I** alone.

**WARNINGS:** Please note that this guide does not cover all irregular electrical activities and rhythms of the heart. This guide contains simulated and real examples of ECG tracings. This guide is for reference **ONLY**. If you find your ECG tracing different from a normal sinus rhythm, or if the tracing resembles any of the irregular ECG tracings, please consult a physician for advices.

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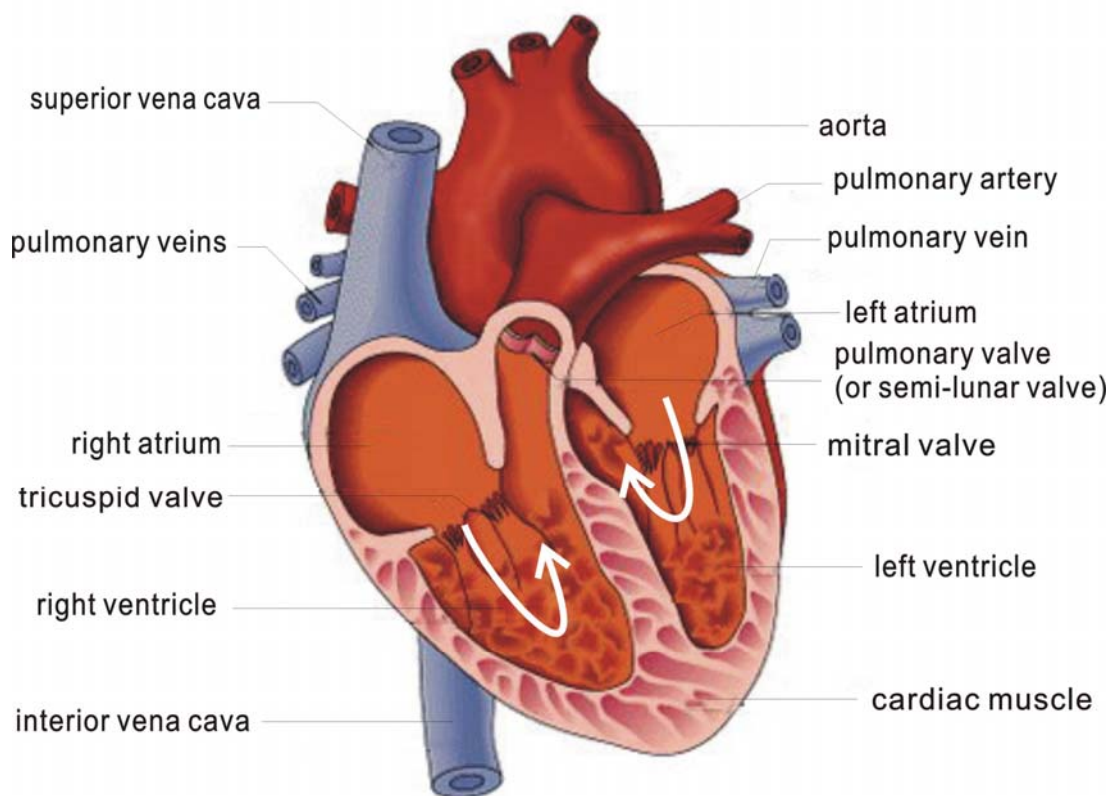
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# Cardio System

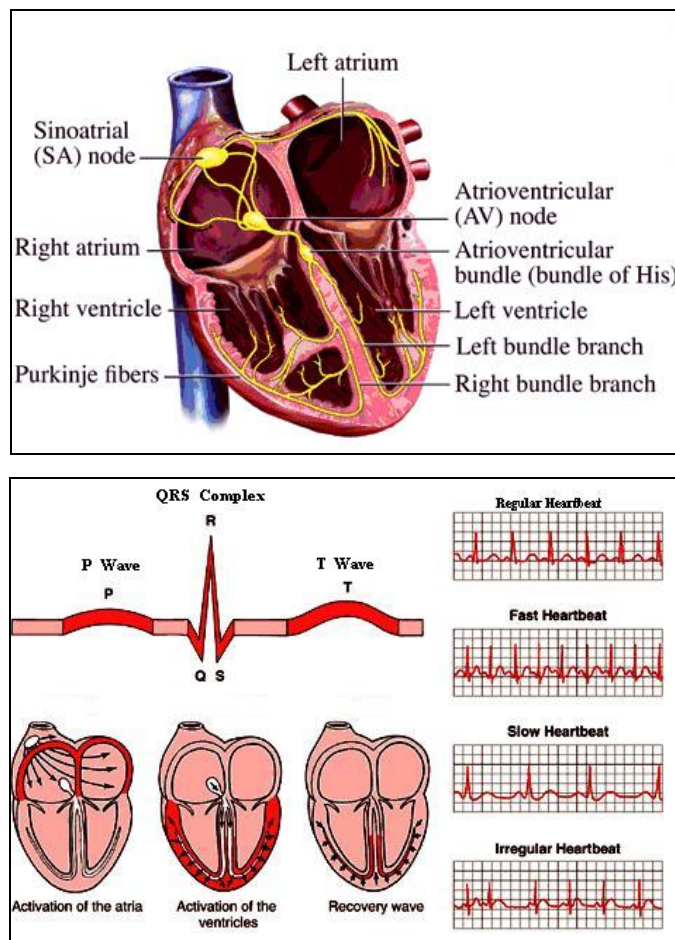
## 1.1 Basic Function of the Heart:

The heart has 4 chambers that act together to pump blood throughout the body. The 2 smaller upper chambers are called atria, and the larger lower chambers are called ventricles. The right atrium receives oxygen-depleted blood coming back from the body via 2 large veins: the superior vena cava and inferior vena cava. The right atrium pumps this blood into the right ventricle, which then pumps the blood into the lungs, which is oxygenated. The blood then comes back into the left atrium, which is then pumped into the left ventricle. The left ventricle then pumps the blood back to the circulatory system via the aorta, the largest artery in the body. The pressure that the left ventricle exerts to keep the blood moving throughout the whole body is the blood pressure.



## 1.2 Conduction System of the Heart:

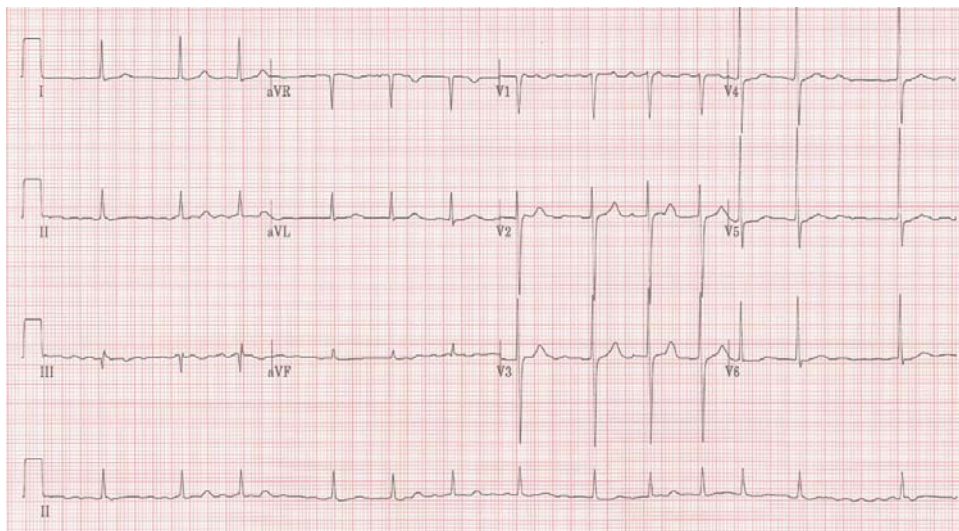
The chambers of the heart pump with the automatic discharge of electricity from the sinoatrial (SA) node, a group of specialized cells located in the right atrium, also known as the heart's natural pacemaker. On average, there are 60 to 100 times discharges per minute. When the SA node discharges, both atria contract, and the electrical impulse is relayed to the atrioventricular (AV) node, located between the 2 ventricles. The electrical wave is then transmitted from the AV node to the lower chambers of the heart, or ventricles, via the "bundle branches". The ventricles will contract and pump blood to the whole body. The normal delay between the atrium and ventricle contractions is 0.12 to 0.20 seconds. By studying the electrical activity that results when heart muscle cells contract, we gain insight to the health and workings of the heart. These electrical activities can be detected, recorded and studied with an electrocardiograph, for example ReadMyHeart.



## 1.3 About Arrhythmia:

Arrhythmia is an abnormal or irregular hear rhythm resulting from any changes, deviation or malfunction in the conduction system of the heart. Early diagnosis of an arrhythmia is very important. This is because the longer an arrhythmia lasts without any detection or treatment, the greater the chances of permanent damage and additional heart dysfunction.

## 1.4 Example of 12-Lead ECG:

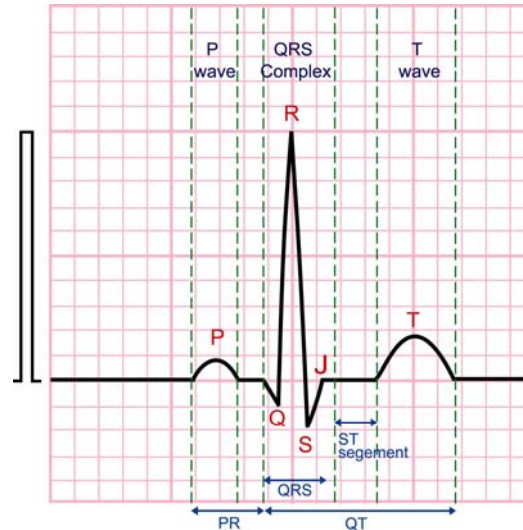


(Arrhythmia)

# Basis of the Electrocardiogram (ECG)

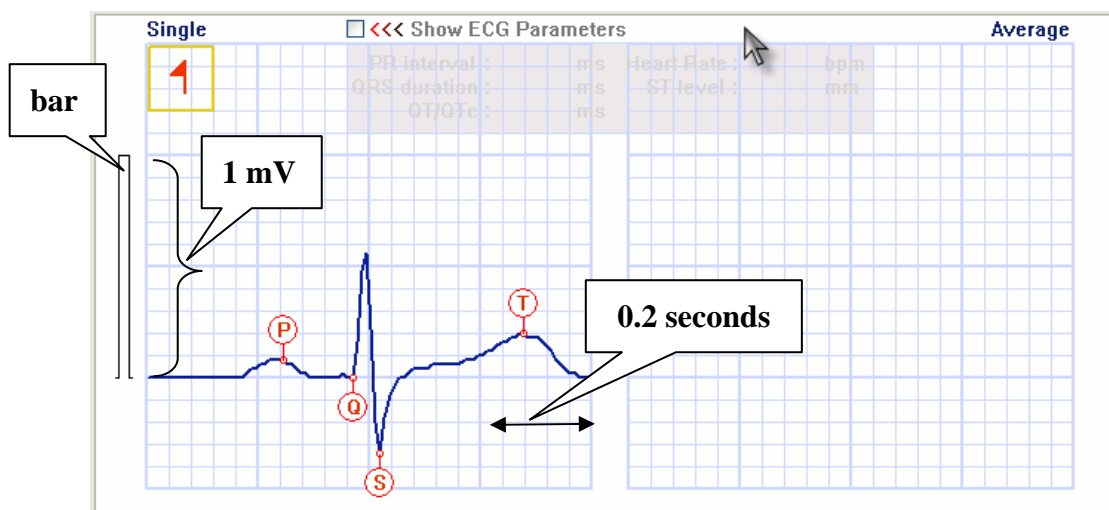
## 2.1 Understanding ECG Parameters:

- A normal ECG Waveform (Lead I)



- Reading the graph

The Y-axis represents voltage in mV. The bar indicated below represents 1 millivolt (mV). This denotes the electrical strength of the signal. Therefore, each big square represent 0.5 mV and each small square represent 0.1mV. The X-axis represents time in seconds. Each big square represent 0.2 seconds. Therefore, each small square represents 0.04 seconds.





## 2.2 ECG waves and parameters

The following is a summary of the ECG wave morphologies and parameters that users can use as a guide to understand more about their ECG recordings.

- **P wave:** The P wave results from atria contraction. P wave is generally about 1 box wide or 1 box tall. P wave that exceeds these might indicate atria hypertrophy, i.e., enlargement.
- **PR Interval:** The PR interval is measured from the start of the P wave to the start of Q wave. It represents the duration of **atria depolarization**. Regular duration is from **0.12 to 0.20 seconds, about 3 to 5 box wide**. If the PR interval is greater than 0.20 seconds, then an AV block might be present.
- **QRS Complex:** The QRS complex is measured from the start of Q wave to the end of S wave. It represents the duration of **ventricle depolarization**. Regular duration is from **0.08 – 0.12 seconds, about 2 to 3 box wide**. If duration is longer, it might indicate presence of bundle branch blocks.
- **QT/QT<sub>c</sub>:** The Q T/QT<sub>c</sub> is measured from the start of the Q wave to the end of T wave. QT interval represents the duration of **activation and recovery of the ventricular muscle**. This duration varies inversely with the heart rate. The regular QT<sub>c</sub> is approximately **0.41** seconds or an accurate measurement, it is corrected with the heart rate with the following formula to get QT<sub>c</sub>:

$$QT_c = QT + 1.75 (HR - 60)$$

- **ST Segment:** The ST segment is measured from end of S wave, J point, to the start of T wave. This segment is important in identifying pathology such as myocardial infarctions (elevations) and ischemia (depressions).



## ■ ECG Parameters:

Parameters	Reference Range
Average Heart Rate (HR)	60 < HR < 100 bpm
ST Segment (ST)	-2 < ST < +2 mm
QRS Interval (QRS)	0.08 < QRS < 0.12 sec
PR interval	0.12 ~ 0.20 sec
QT/QT <sub>c</sub>	0.32 ~ 0.44 sec / 0.41 ~ 0.44 sec

Note: The information above is for reference ONLY. If the measured parameters fall within the reference range and the user still feel any discomfort, please consult your physician. Data generated by RMH can be provided to the physicians for reference and further analysis.

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## Cautions:

- The followings are some simulations and examples of Lead I ECG tracings.
- Please NOTE that these simulations and examples of ECG irregularities are from Lead I only.
- Professionals need to perform a standard 12 lead ECG and/or other tests before diagnosing your exact heart conditions.



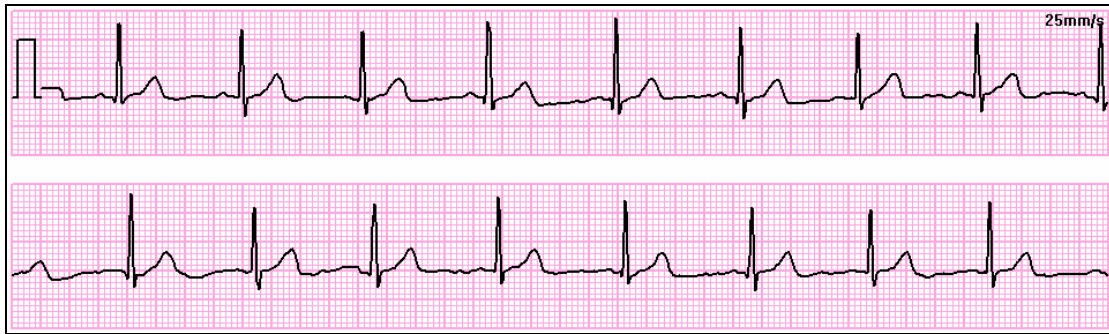
## Warnings:

This guide is for you to understand some of the many ECG irregularities through Lead I ONLY. You should NOT self-diagnosis and self-medicate based on this guide or Lead I ECG alone.

# ECG Tracing

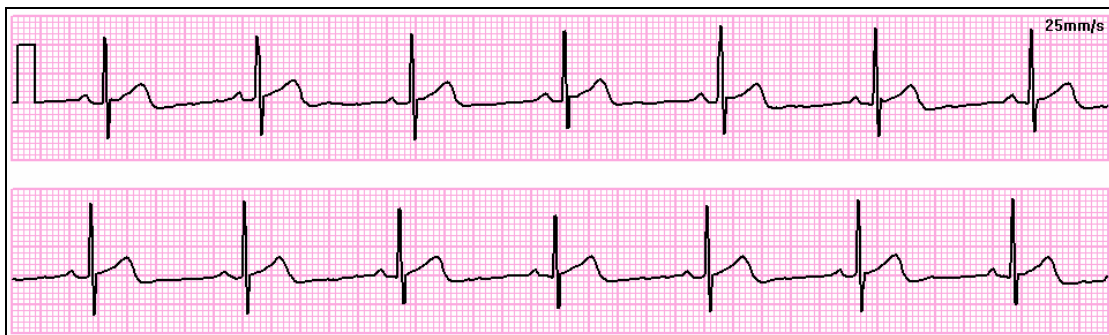
## 3.1 Normal Sinus Rhythm

- **Descriptions:** All complexes normal and frequency is between 60 to 100 beats per minute.



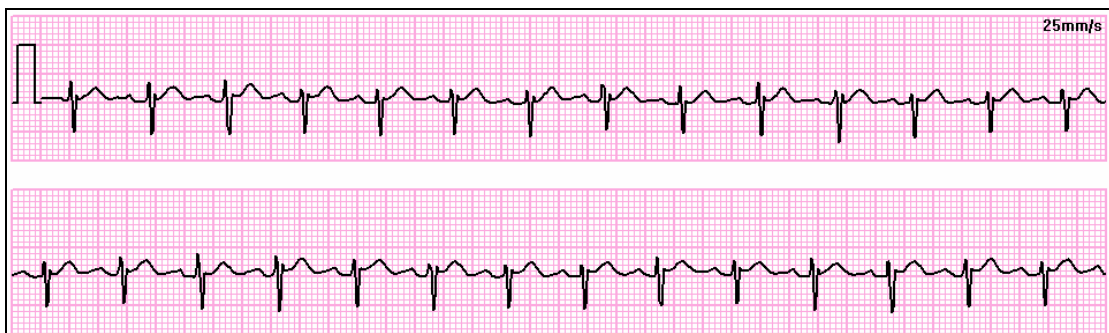
## 3.2 Sinus Bradycardia

- **Descriptions:** A sinus rhythm of less than 60 beats per minute.



## 3.3 Sinus Tachycardia

- **Descriptions:** The sinus node sends out electrical signals faster than usual, speeding up the rate. A sinus rhythm of more than 100 beats per minute.



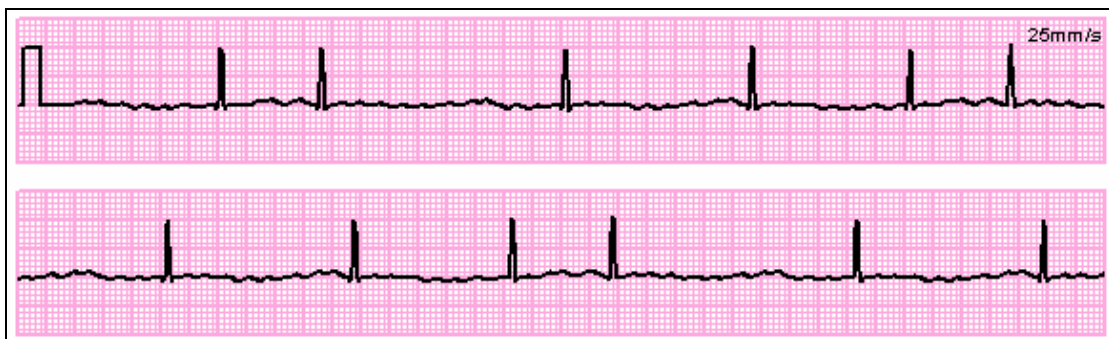
### 3.4 Supraventricular Tachycardia (SVT)

- **Descriptions:** Usually caused by reentry currents within the atria or between ventricles and atria producing higher heart rates of 140~250. (Sinus rhythm at 160 BPM.)



### 3.5 Atrial Fibrillation, Coarse

- **Descriptions:** Rapid irregular atrial signal with no real P-waves. Irregular ventricular rate.



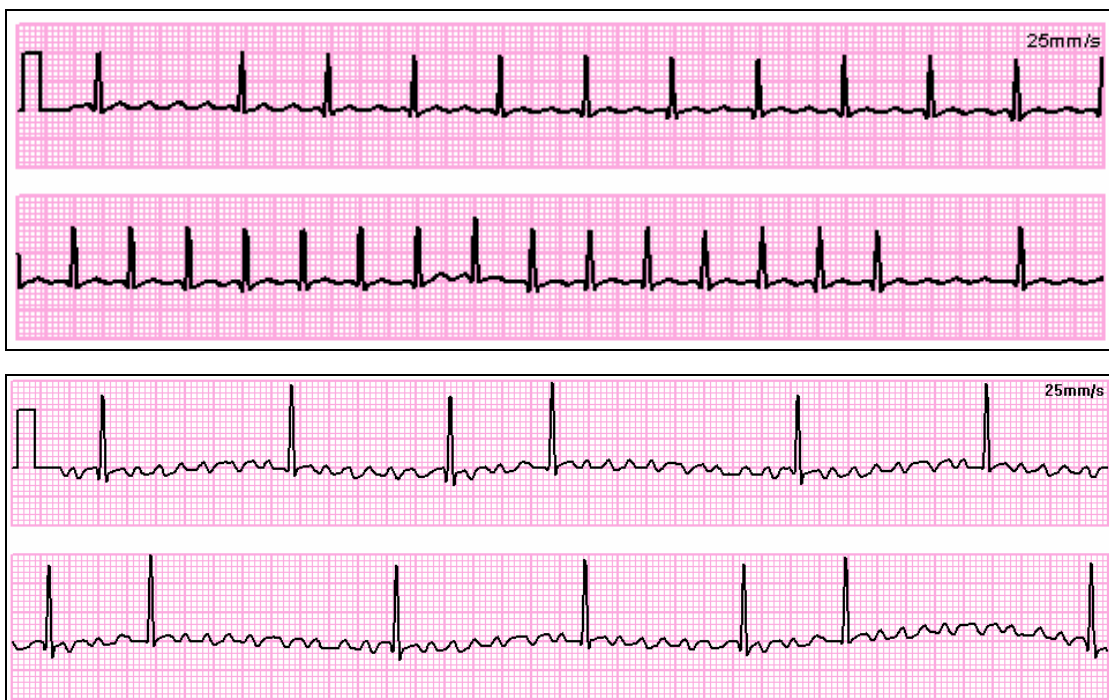
### 3.6 Atrial Fibrillation, Fine

- **Descriptions:** Rapid irregular atrial signal with no real P-waves. Irregular ventricular rate.



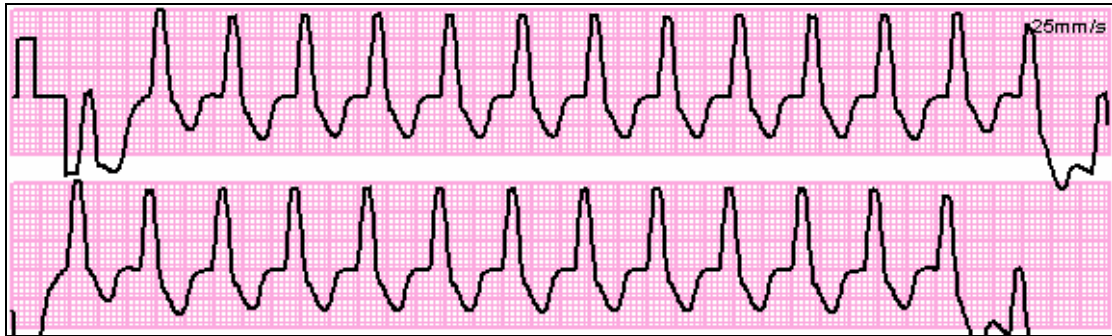
### 3.7 Atrial Flutter

- **Descriptions:** Large regular P-waves (sinus rate of 250~350BPM). Ventricular response varies.



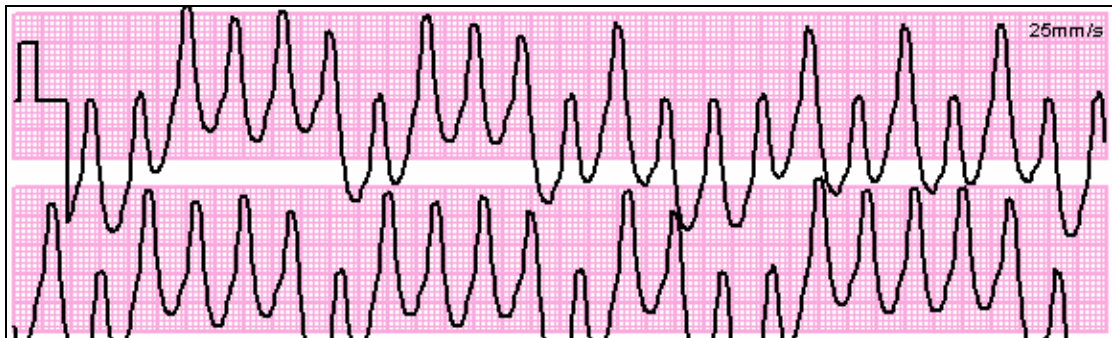
### 3.8 Ventricular Rhythm

- **Descriptions: (Extremely Serious-near death conditions)** Similar to left focus PVCs at 120 BPM



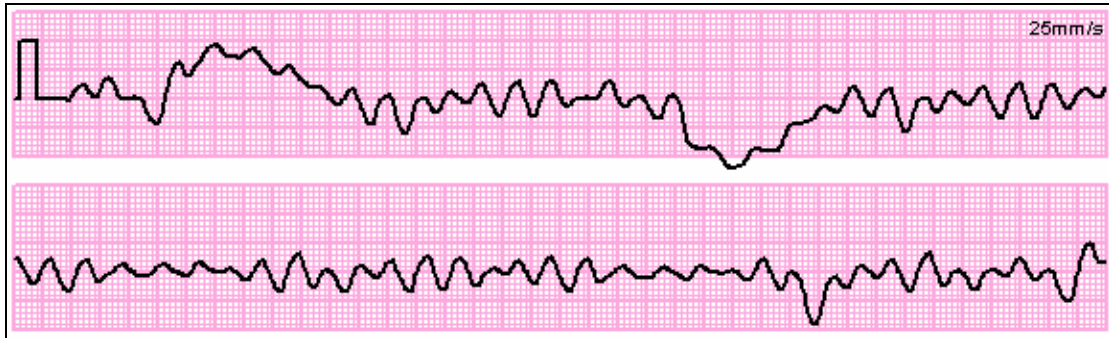
### 3.9 Ventricular Tachycardia

- **Descriptions: (Extremely Serious-near death conditions)** Similar to left focus PVCs at 180BPM



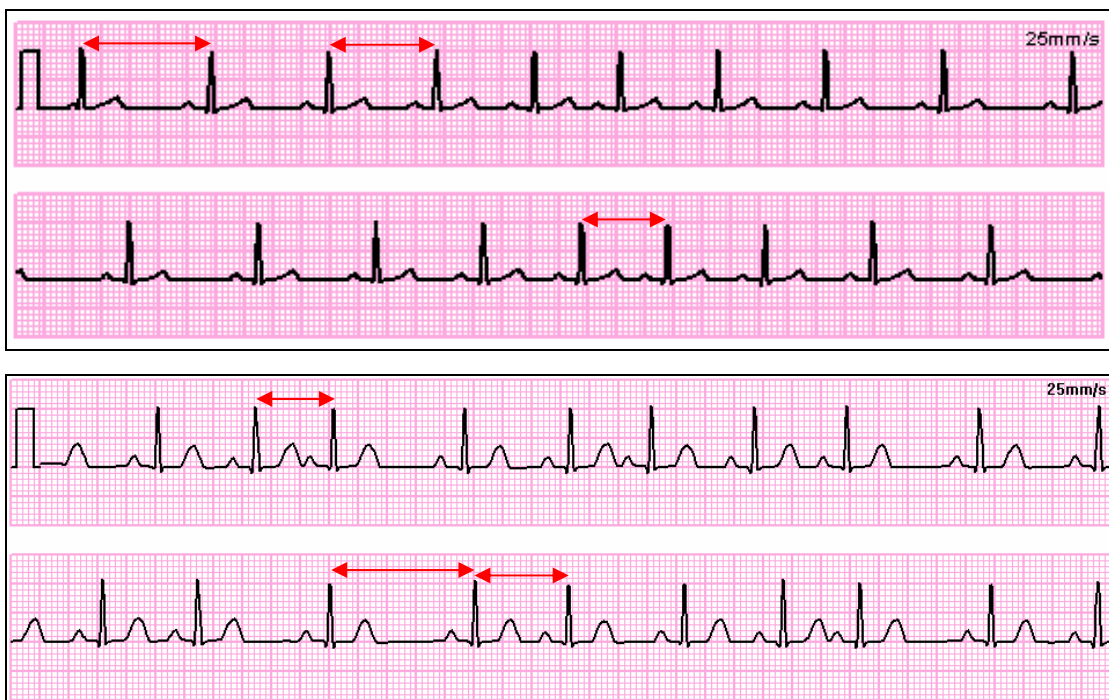
### 3.10 Ventricular Fibrillation

- **Descriptions:** (Extremely Serious-near death conditions) Irregular ventricular waveform



### 3.11 Sinus Arrhythmia

- **Descriptions:** Normal beats, but triggered at an irregular interval from 60 to 100 BPM, causing varying R-R interval.

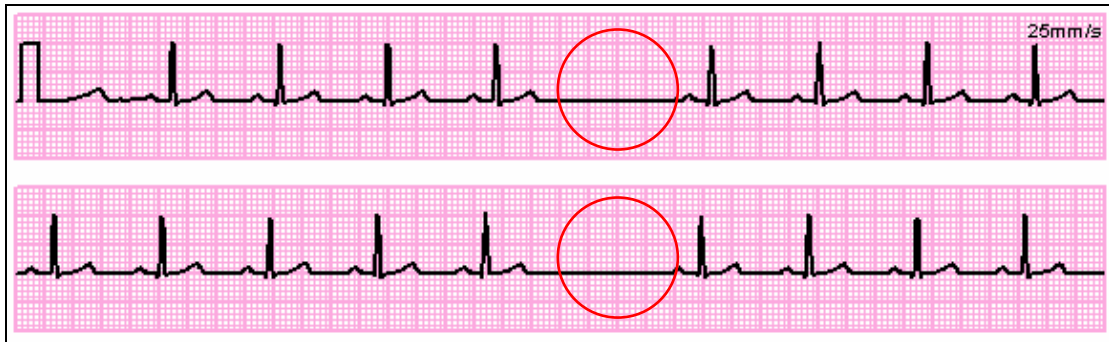




### 3.12 Missed beat

#### A. Missed beat at 80 BPM

- **Descriptions:** Missed beat at 80 BPM. Normal sinus rhythm, but every 10<sup>th</sup> beat is missing



#### B. Missed beat at 120 BPM

- **Descriptions:** Missed beat at 120 BPM. Normal sinus rhythm, but every 10<sup>th</sup> beat is missing





### 3.13 Paroxysmal Atrial Tachycardia (PAT)

- **Descriptions:** A repeated periods of very fast heartbeat which begin and ends suddenly. 160 BPM for 5 seconds alternating with normal sinus rhythm at 80 BPM.



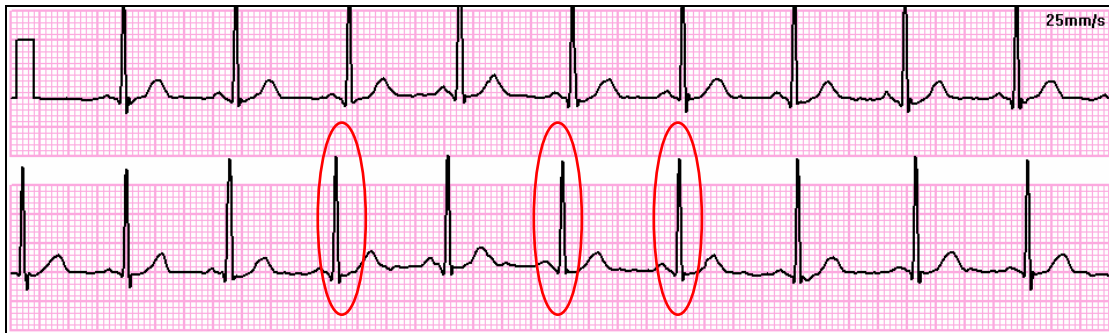
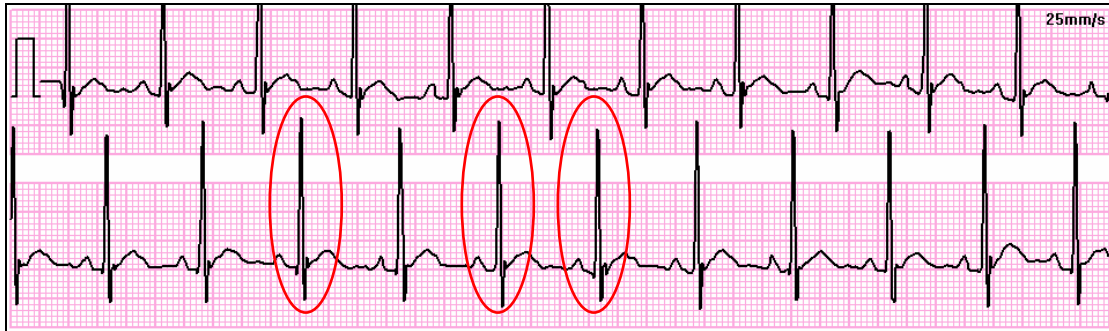
### 3.14 Nodal Rhythm

- **Descriptions:** Normal sinus rhythm except P-wave originates in the AV node instead of SA node. Shortened PR interval of 0.09 seconds.



### 3.15 Left Ventricular Hypertrophy

- **Descriptions:** Tall R wave caused by possible thickening of heart muscle wall.



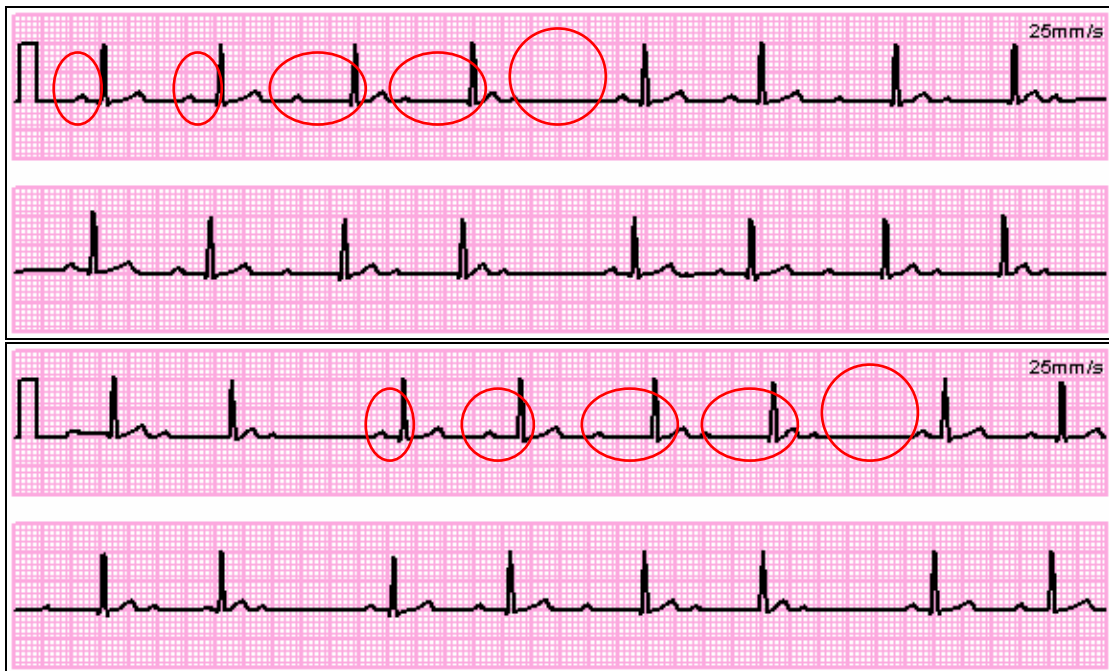
### 3.16 First Degree A-V Heart Block:

- **Descriptions:** P wave always precedes the QRS complex, but PR interval is prolonged over 0.2 second, or 5 small squares. Missed beats are from occasional signals not reaching the ventricles.



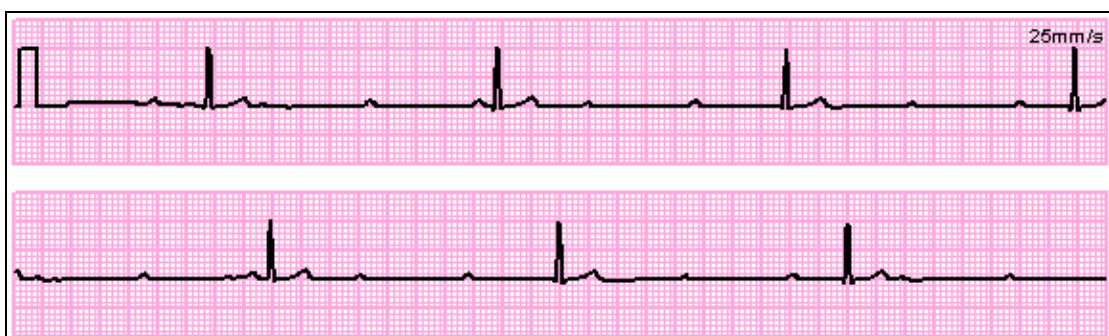
### 3.17 Second Degree A-V Heart Block:

- **Descriptions:** PR interval progressively lengthens and leading finally to the dropout of QRS complex, also known as *Wenkebach Phenomenon*.



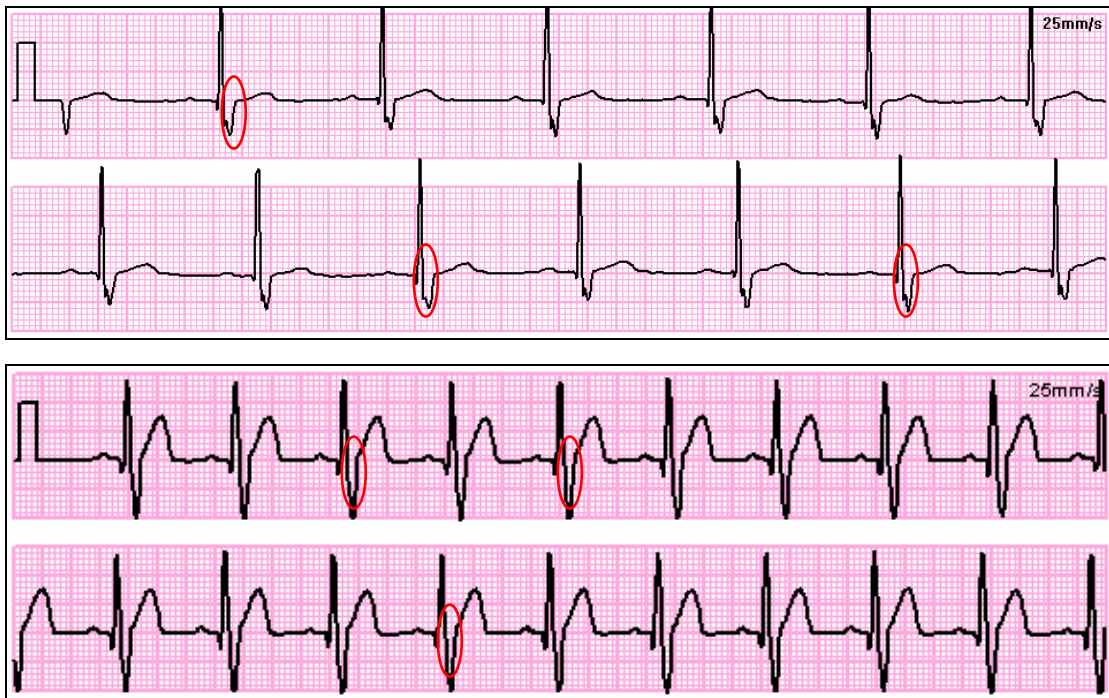
### 3.18 Third Degree A-V Block:

- **Descriptions:** Complete lack of synchronism between the P wave and QRS complex. No signals reaching ventricles.



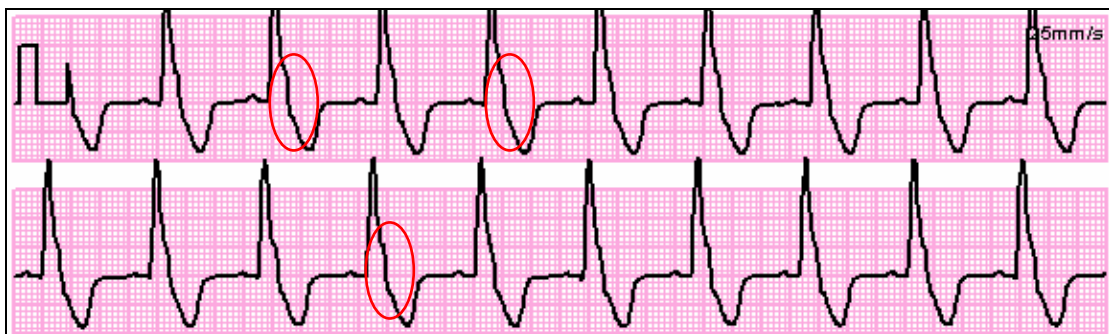
### 3.19 Right Bundle Branch Block (RBBB)

- **Descriptions:** Wide QRS, usually more than 120ms or 3 small squares, and wide S wave, caused by partial or complete blockage of signal along the right branch below the bundle of HIS.



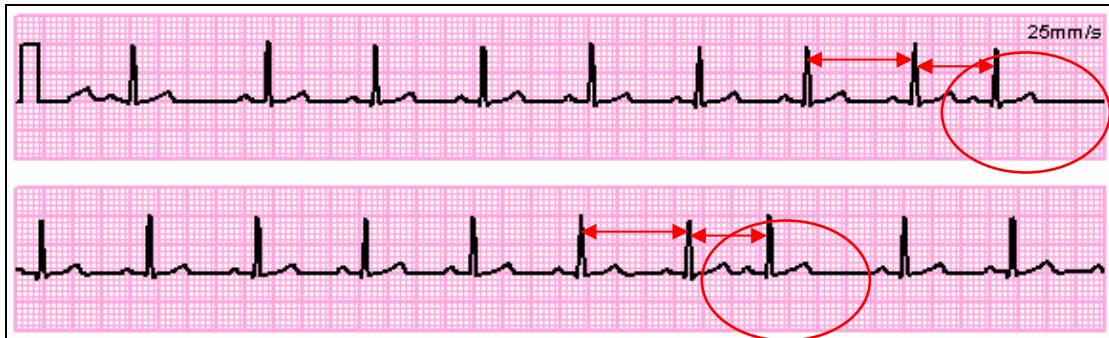
### 3.20 Left Bundle Branch Block (LBBB)

- **Descriptions:** Wide QRS, and wide S wave, caused by partial or complete blockage of signal along the right branch below the bundle of HIS.



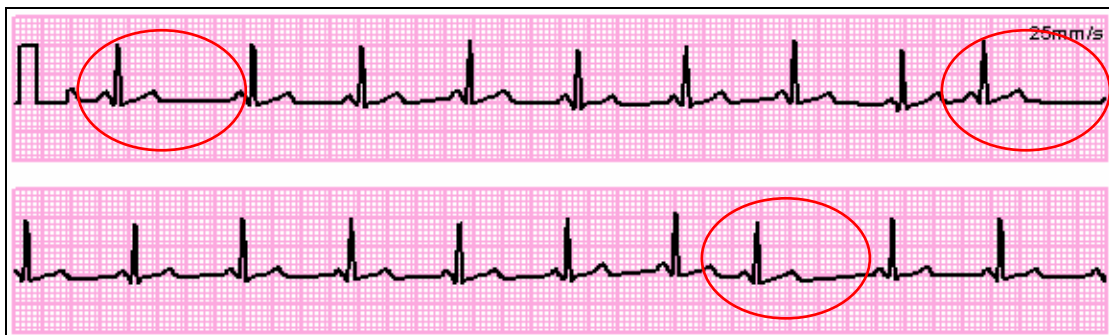
### 3.21 Premature Atrial Contraction (PAC)

- **Descriptions:** A beat occurs early in the atria causing the heart to beat before the next regular beat.



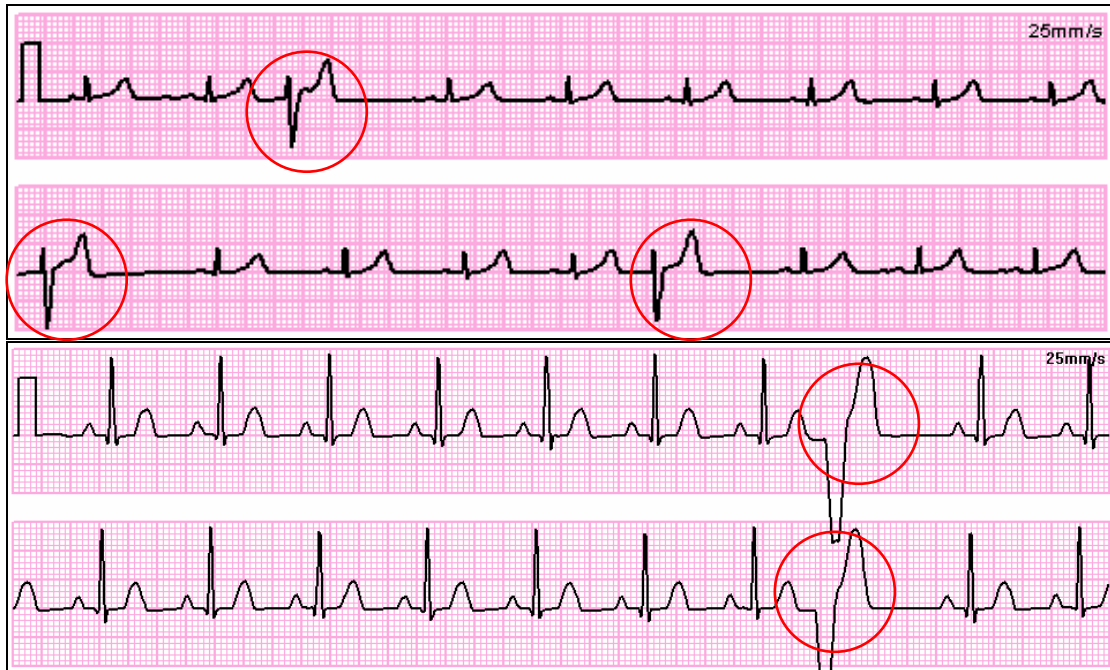
### 3.22 Premature Nodal Contraction (PNC)

- **Descriptions:** A beat occurs early in the AV node causing the heart to beat before the next beat. (Nodal rhythm – a cardiac rhythm paced by the AV node – short PR interval)



### 3.23 Premature Ventricular Contraction (PVC)

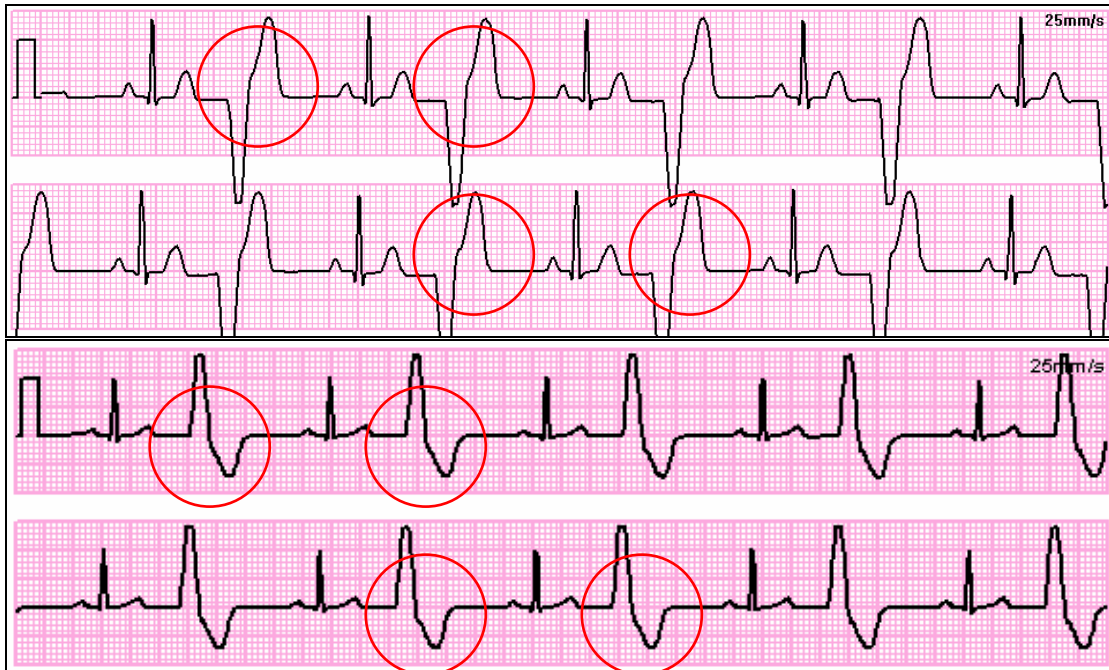
- **Descriptions:** Ventricles contract before signals reached AV node. Time interval between normal R peaks is a multiple of R-R intervals.





### 3.24 Bigeminy

- **Descriptions:** Each normal beat (normal R-R) is followed by a premature contraction (PVC).



### 3.25 Trigeminy

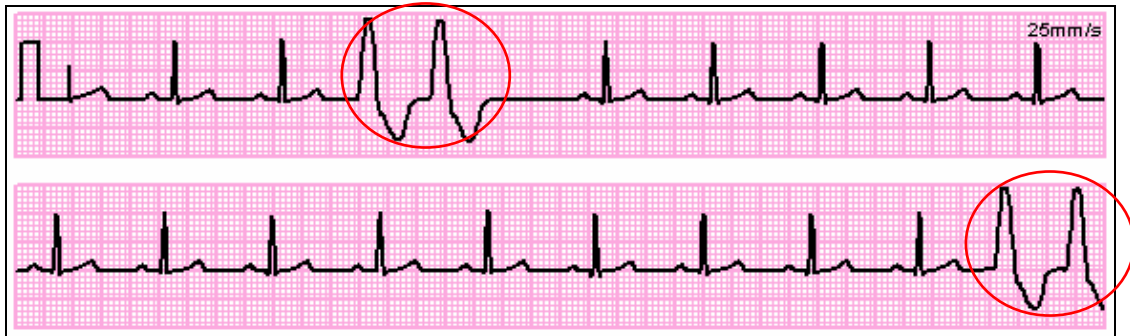
- **Descriptions:** Every second beat is followed by a premature contraction (two normal QRS complexes followed by a PVC).





### 3.26 Two PVCs together – Couplet

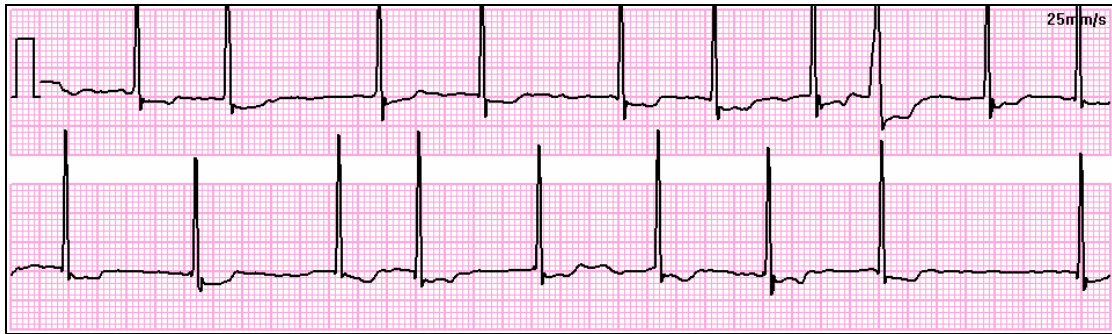
- **Descriptions:** Two PVCs together. Also called a couplet.



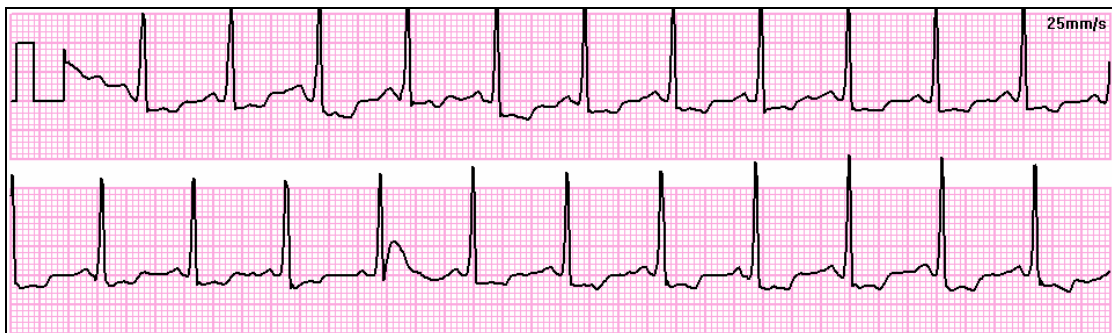
## OTHER EXAMPLES

### 4.1 Irregular ECG

- **Descriptions:** Arrhythmia, ST depression, reverse T wave

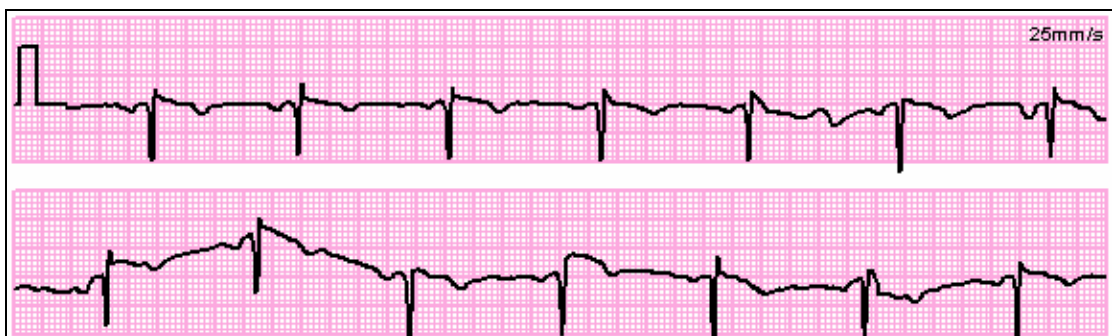


- **Descriptions:** ST depression, reverse T wave



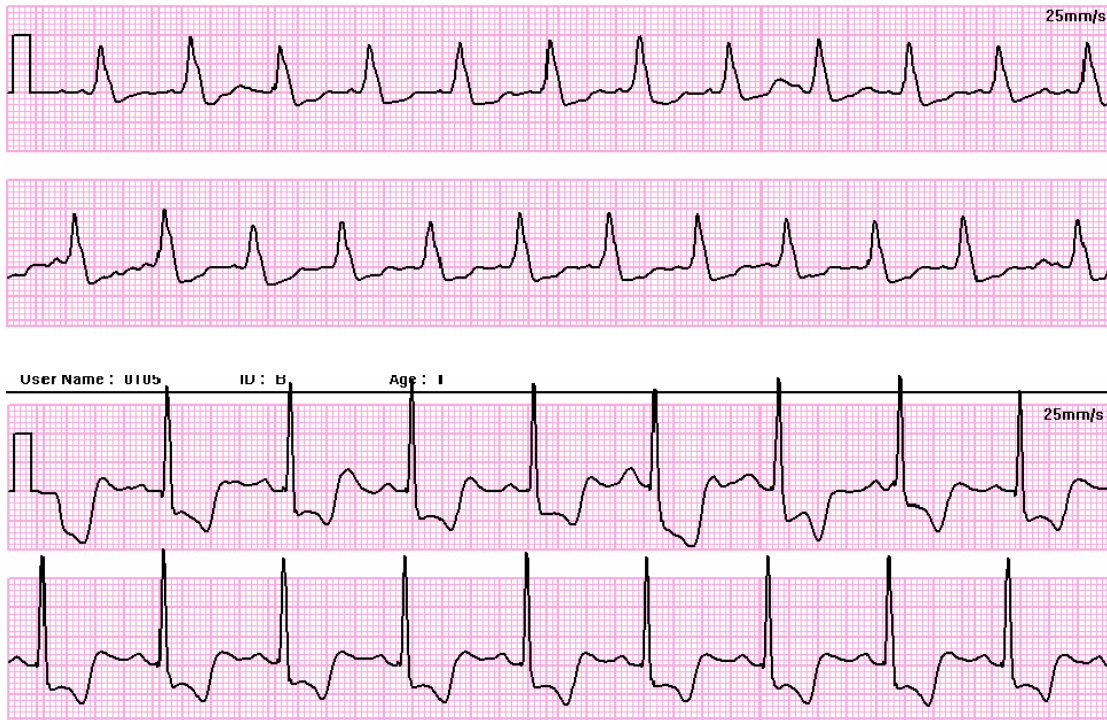
### 4.2 Reverse Signals

- **Descriptions:** Reverse positioning of heart, all signals reversed



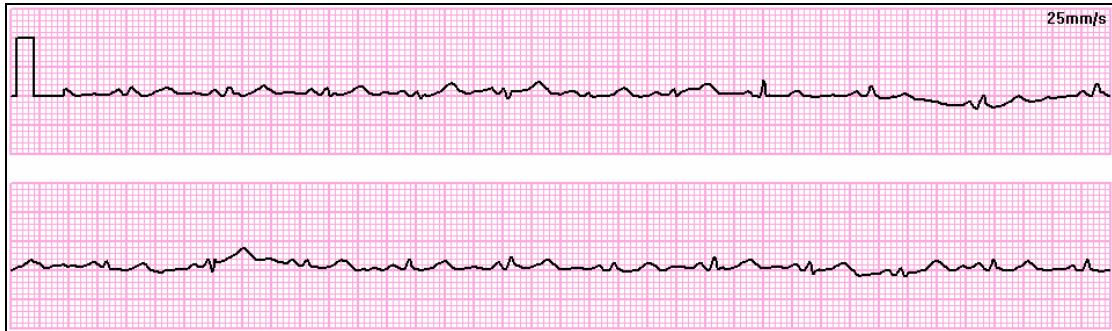
## 4.3 Pacemaker moniting

- **Descriptions:** ECG tracing of users with pacemakers.

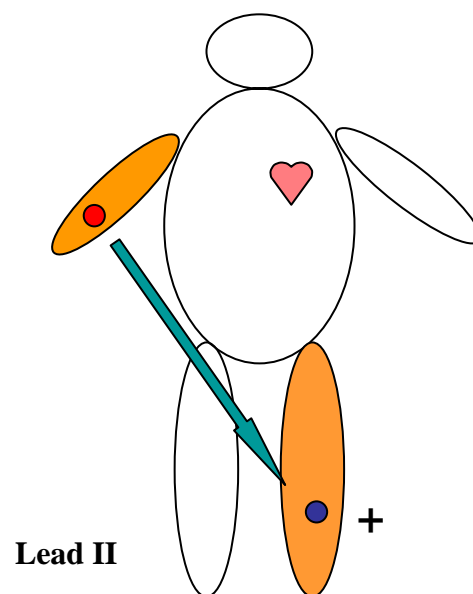
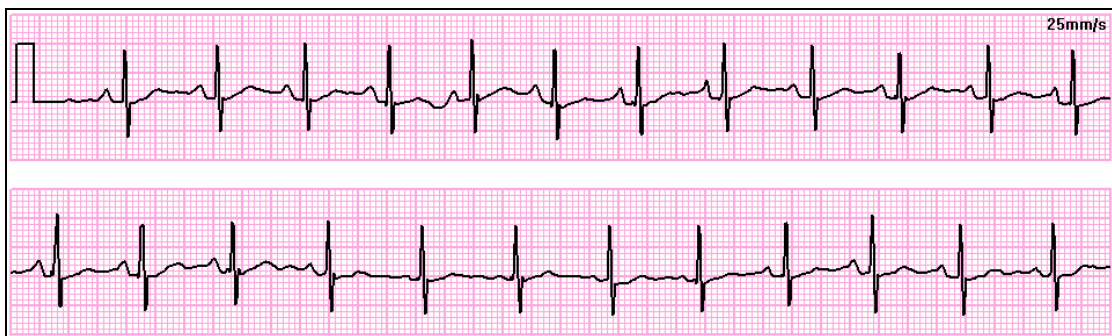


## 4.4 Small Signals

- **Descriptions:** Small signals from Lead I (Suggestion: Use Lead II)

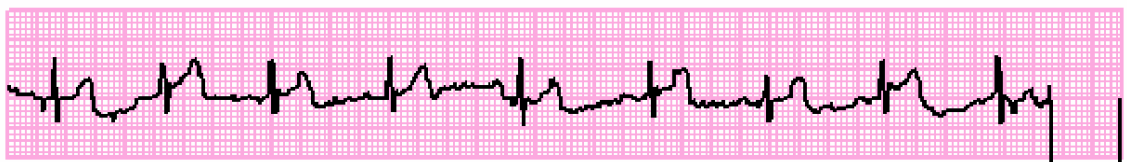
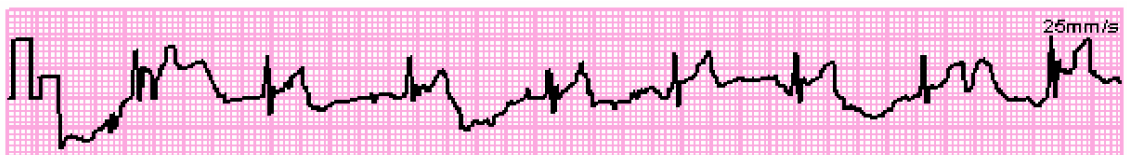


- **Descriptions:** Lead II for the above ECG (Right arm and Left leg)

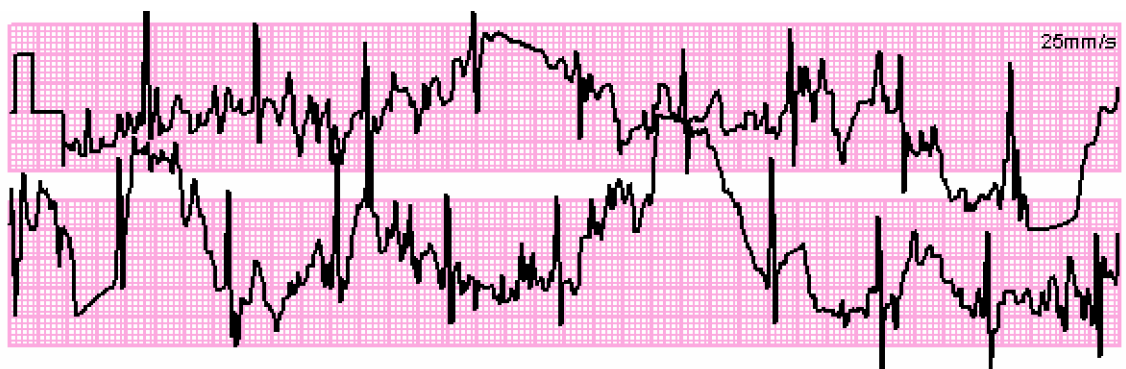


## 4.5 Noise Signals

- **Descriptions:** The “Noise” is the interference with the recording of these signals due to poor contact between the thumbs and the electrodes, excessive movement of the body, and other the environment, etc. Please follow standard operating procedure and measure again.



- Dry thumbs, Unclean thumbs, Unclean electrodes
- Unstable environments



- Small movement during measurement, (talking & breathing)
- Dry thumbs, Unclean thumbs, Unclean electrodes
- Unstable environment

## GLOSSARY:

<b>Aorta</b>	The main trunk of the systemic arteries, carrying blood from the left side of the heart to the arteries of all limbs and organs except the lungs.
<b>Arrhythmia</b>	Irregularity in the force or rhythm of the heart beat.
<b>Atrioventricular (AV) node</b>	A small mass of specialized cardiac muscle fibers, located in the wall of the right atrium of the heart, that receives heartbeat impulses from the sinoatrial node and directs them to the walls of the ventricles.
<b>Bundle of His</b>	A slender bundle of modified cardiac muscle that passes from the atrioventricular node in the right atrium to the right and left ventricles by way of the septum and that maintains the normal sequence of the heartbeat by conducting the wave of excitation from the right atrium to the ventricles called also <i>atrioventricular bundle</i> , <i>His bundle</i> .
<b>Electrocardiogram</b>	The curve traced by an electrocardiograph.
<b>Electrocardiograph</b>	An instrument used in the detection of heart abnormalities that. It measures electrical potentials on the body surface and generates a record of the electrical currents associated with heart muscle activity.
<b>Heart Rate (HR)</b>	The number of heartbeat per unit time, usually in minutes.
<b>Hypertrophy</b>	A non-tumorous enlargement of an organ or a tissue as a result of an increase in the size rather than number of constituent cells.
<b>Inferior vena cava</b>	Large vein formed by the union of the two common iliac veins that receives blood from the lower limbs and the pelvic and abdominal viscera and empties into the right atrium of the heart.
<b>Left Atrium</b>	Top left chamber of the heart.
<b>Left Ventricle</b>	Bottom left chamber of the heart.
<b>mm</b>	One mm is one small square on the electrocardiograph.
<b>Myocardial Infarction</b>	Formation of an area of tissue that undergo necrosis as a result of obstruction of local blood supply, as by a thrombus or embolus.
<b>P wave</b>	Atrial Depolarization (contraction). Regular duration is 0.06 - 0.11 second.

<b>Parameters</b>	A distinguishing characteristic or feature.
<b>PR Interval</b>	Atrial and AV node depolarization. Regular duration is 0.12 - 0.20 seconds.
<b>QRS Complex</b>	Ventricular depolarization. Regular duration is no longer than 0.1 second.
<b>QT Interval</b>	Ventricular refractory time. Duration varies according to rate, age and sex.
<b>Right Atrium</b>	Top right chamber of the heart.
<b>Right Ventricle</b>	Bottom right chamber of the heart.
<b>Right/Left Bundle Branch</b>	Either of the parts of the bundle of His passing respectively to the right and left ventricles.
<b>Sinoatrial (SA) node</b>	A small mass of specialized cardiac muscle fibers located in the posterior wall of the right atrium of the heart that acts as a pacemaker by generating at regular intervals the electric impulses of the heartbeat.
<b>ST segment</b>	ST segment represents the period from the end of ventricular depolarization to the beginning of ventricular repolarization.
<b>Superior vena cava</b>	A large vein formed by the union of the two brachiocephalic veins and the azygos vein that receives blood from the head, neck, upper limbs, and chest, and empties into the right atrium of the heart.
<b>T wave</b>	Ventricular Repolarization. Usually 0.5mV or less in Lead I, II and III.

### References:

1. American Heart Association [www.americanheart.org](http://www.americanheart.org)
2. eMedicine [www.emedicine.com](http://www.emedicine.com)
3. ECG Library [www.ecglibrary.com](http://www.ecglibrary.com)
4. Guidant Inc. [www.guidant.com](http://www.guidant.com)
5. Heart Center Online [www.heartcenteronline.com](http://www.heartcenteronline.com)
6. National Heart, Lung and Blood Institute [www.nhlbi.nih.gov](http://www.nhlbi.nih.gov)

### Contact:

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Website: [www.dcbiomed.com](http://www.dcbiomed.com)

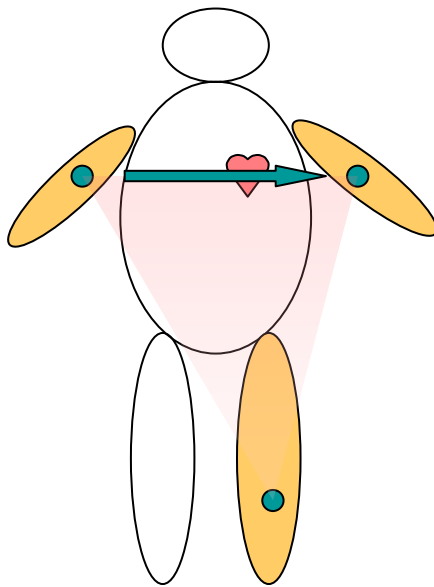
Tel: +886-3-262-1688 Fax: +886-3-261-7688



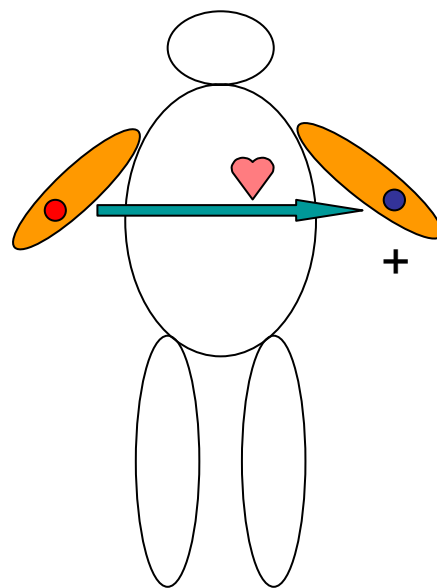
# Appendix

## 12-lead ECG analogy by RMH2.0

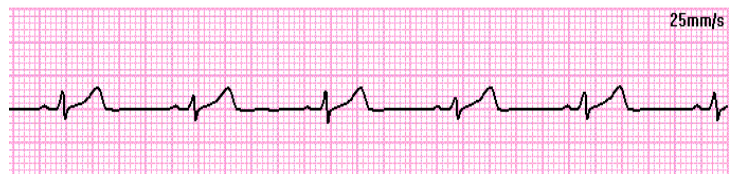
### Lead I



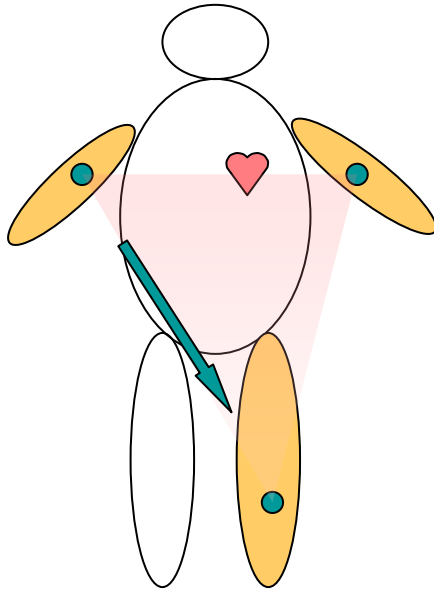
Traditional 3-electrode ECG



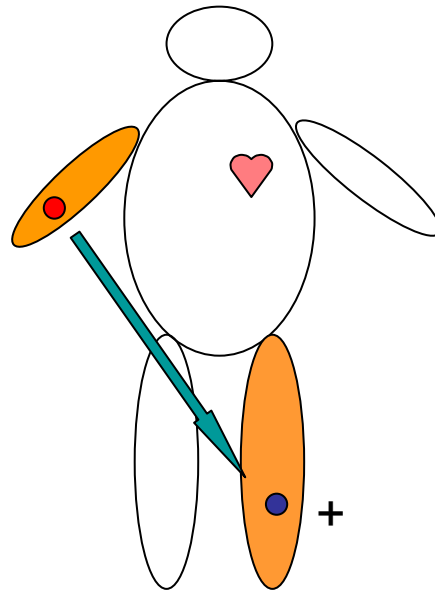
RMH 2.0



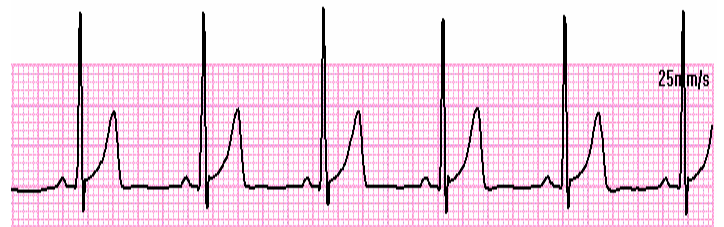
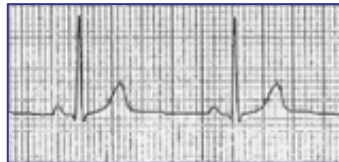
## Lead II



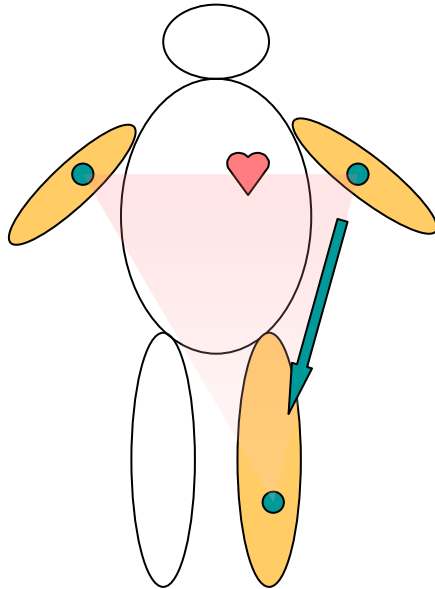
Traditional 3-electrode ECG



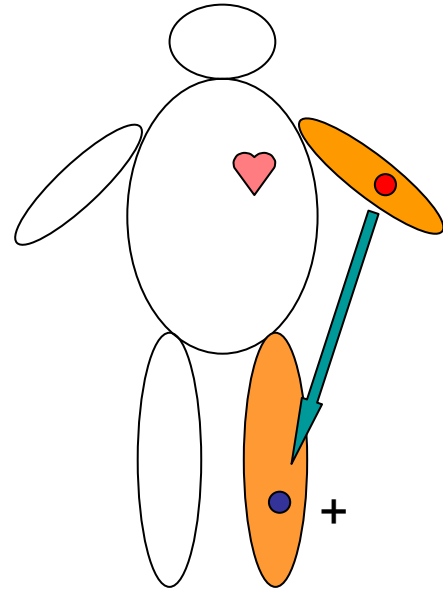
RMH 2.0



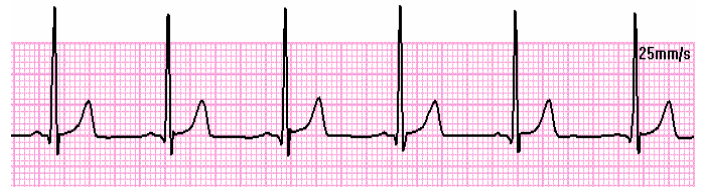
## Lead III



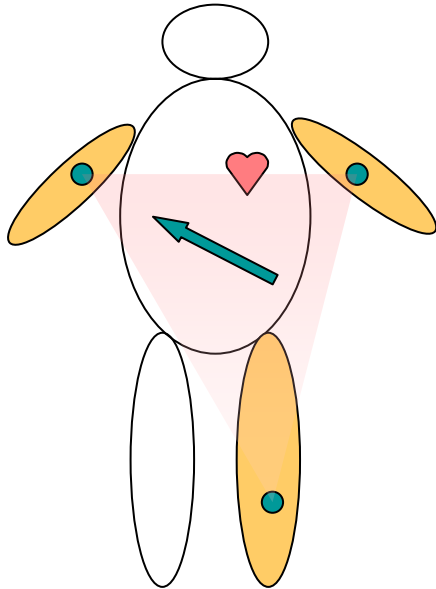
Traditional 3-electrode ECG



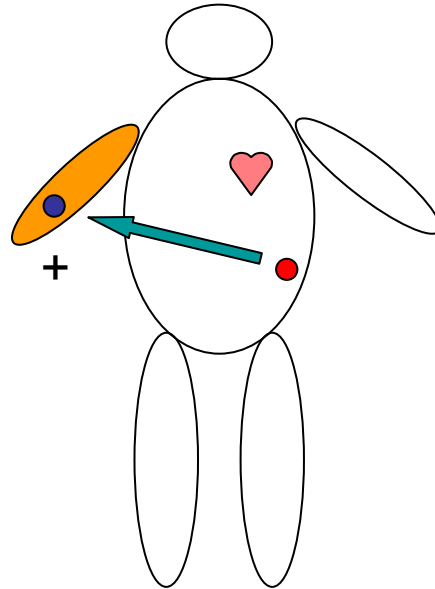
RMH 2.0



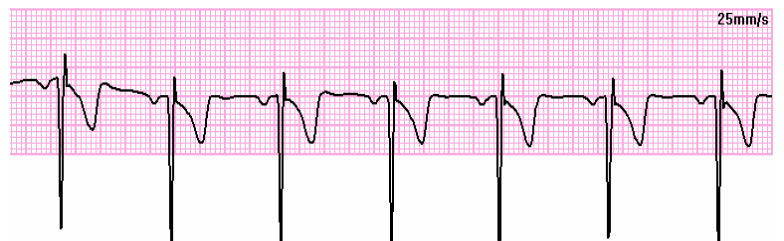
## Lead aV<sub>R</sub>



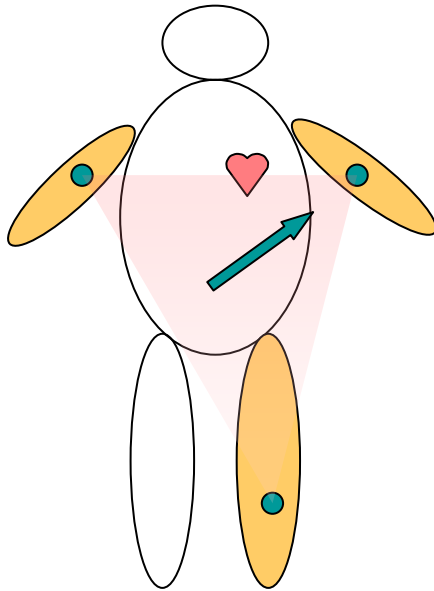
Traditional 3-electrode ECG



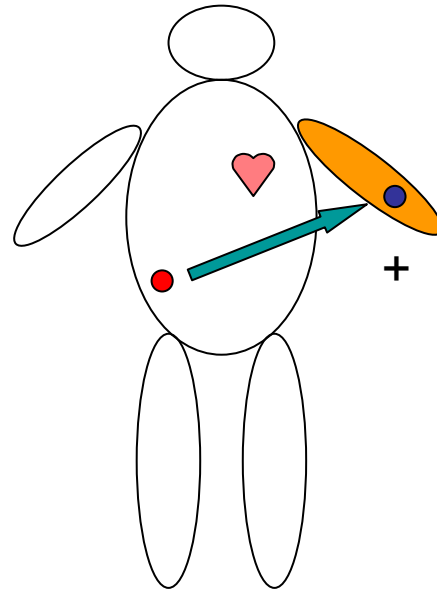
RMH 2.0



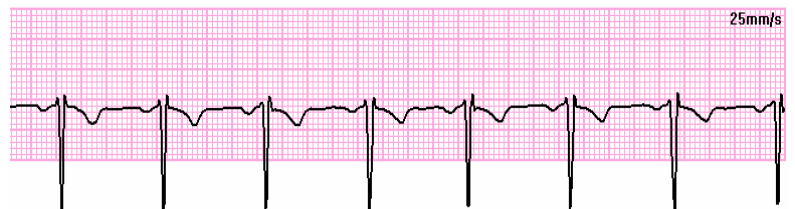
## Lead aV<sub>L</sub>



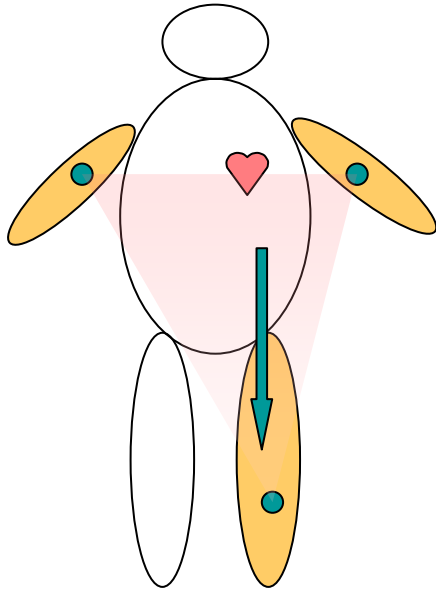
Traditional 3-electrode ECG



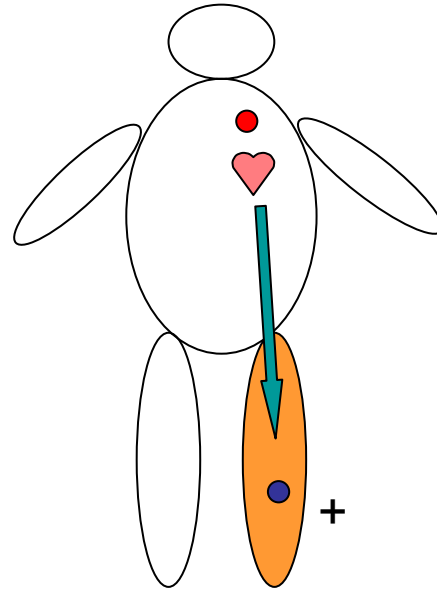
RMH 2.0



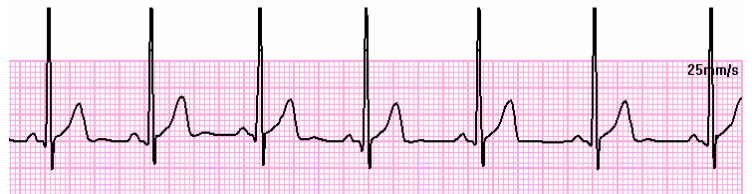
## Lead aV<sub>F</sub>



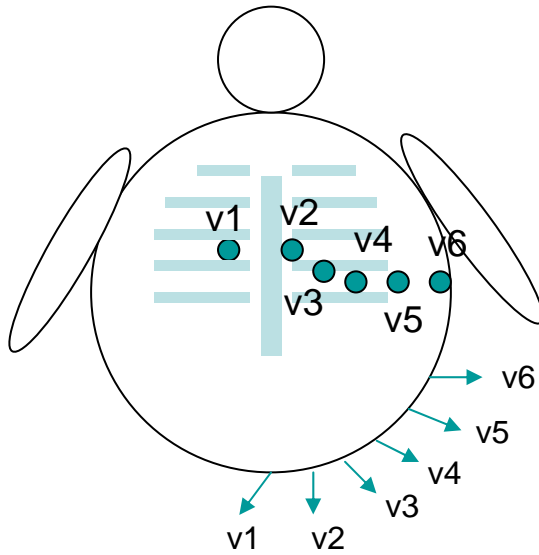
Traditional 3-electrode ECG



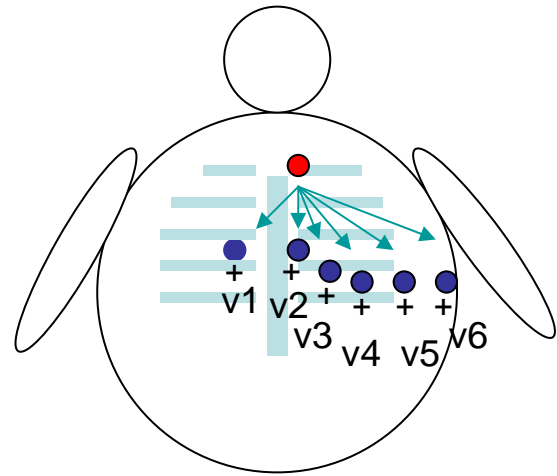
RMH 2.0



# V<sub>1</sub>-V<sub>6</sub>



Traditional 3-electrode ECG



RMH 2.0

