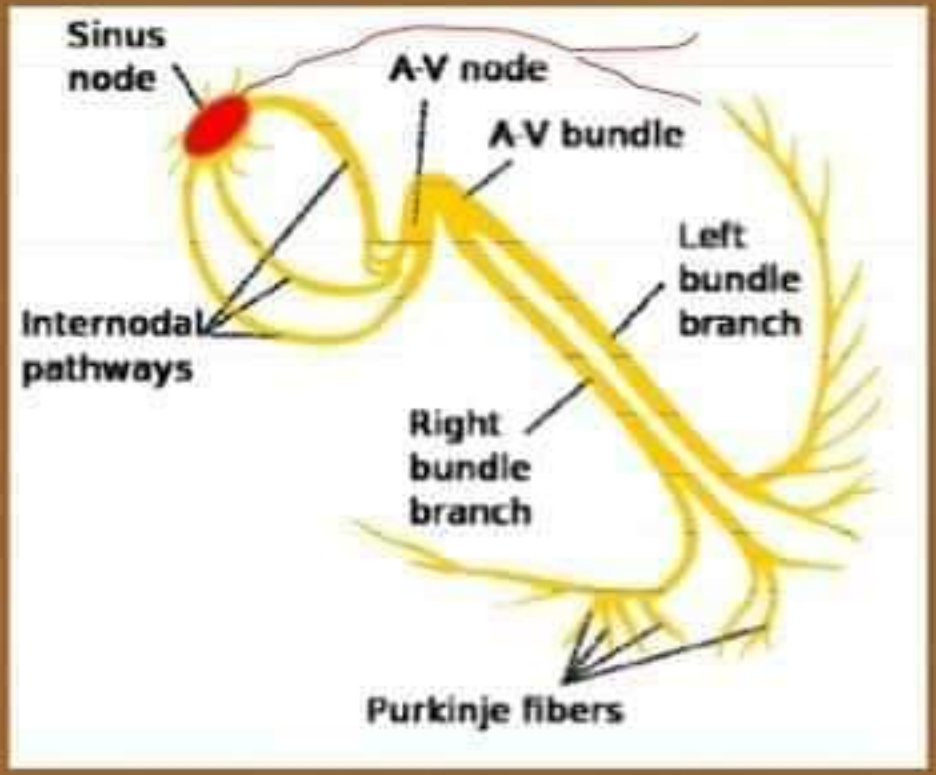
The Basics of Electrophysiology

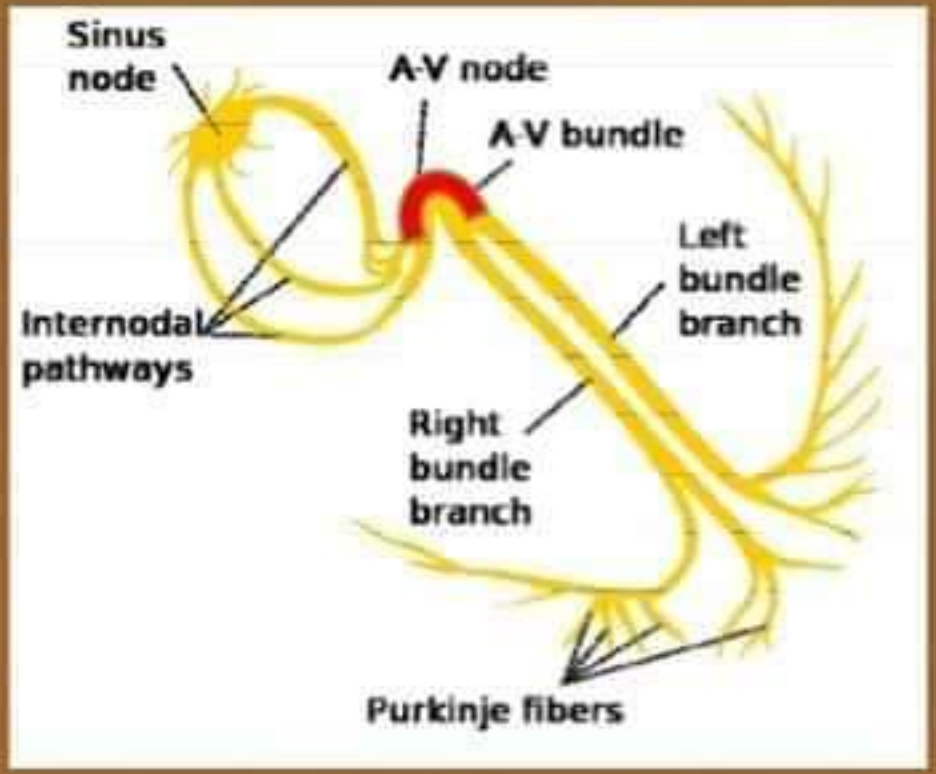
The Basics of Electrophysiology

Bachmann bundle is the SA node pathway that stimulates the left atrium.



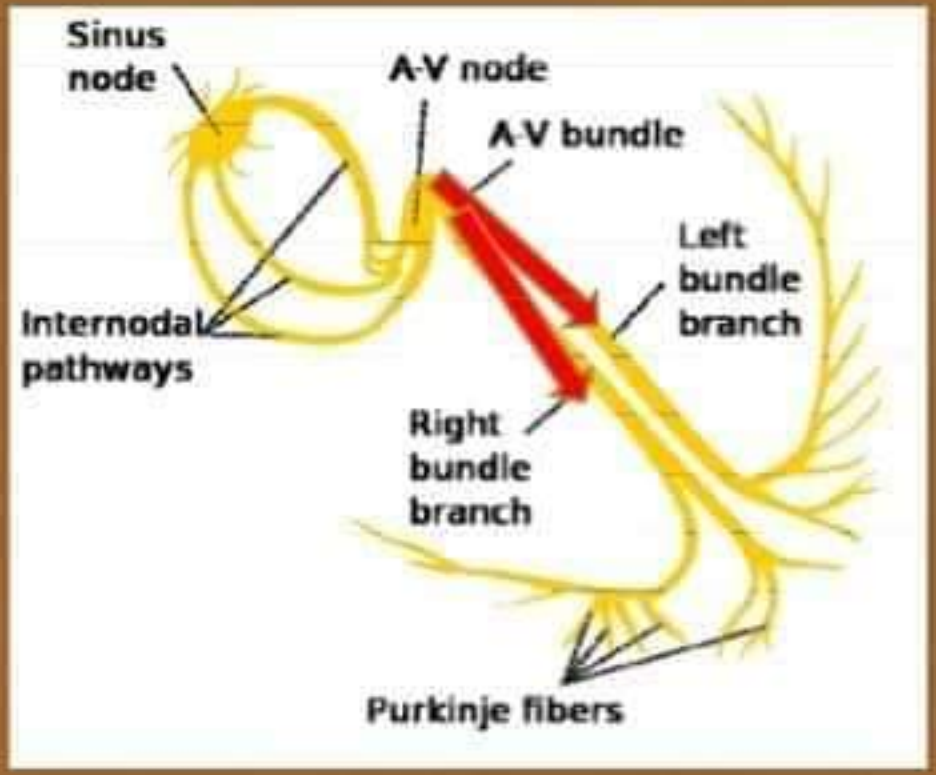
The Basics of Electrophysiology

The AV Node generates about 40-60 stimulations per minutes, if the SA node fails to function.



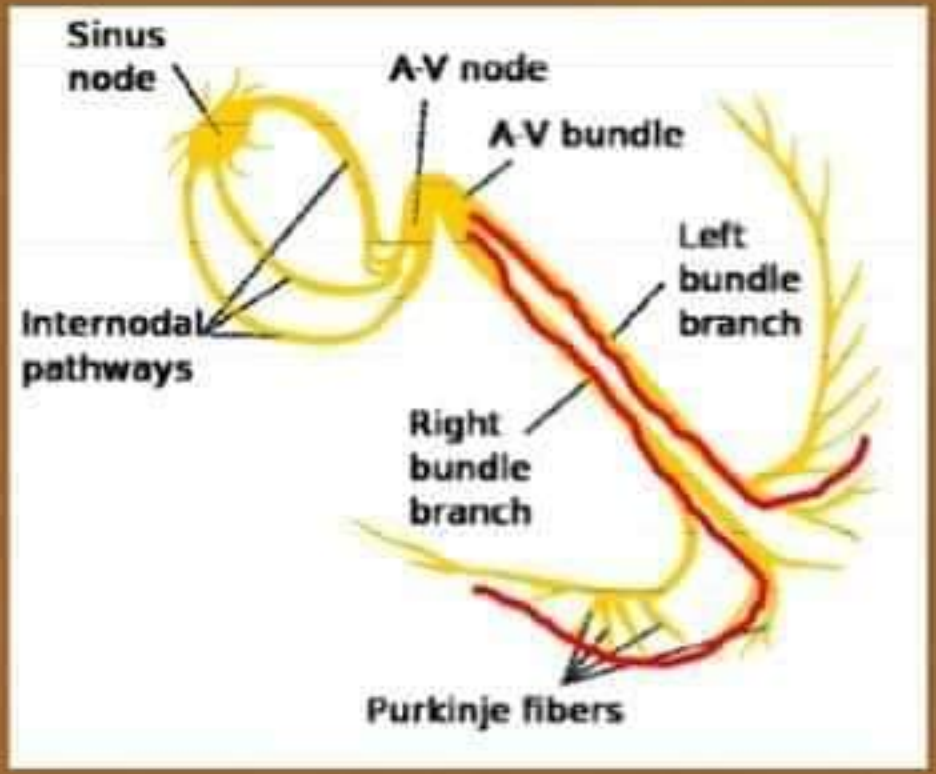
The Basics of Electrophysiology

The AV Bundle (also known as Bungle of His) branches into two main bundle.



The Basics of Electrophysiology

The Left and Right Bundle Branches then attach to the myocardial muscles through Purkinje fibers.



PACEMAKERS

Sinoatrial "SA" Node

- Dominant pacemaker
- Intrinsic rate of 60 - 100 beats/minute.

Atrioventricular "AV" Node

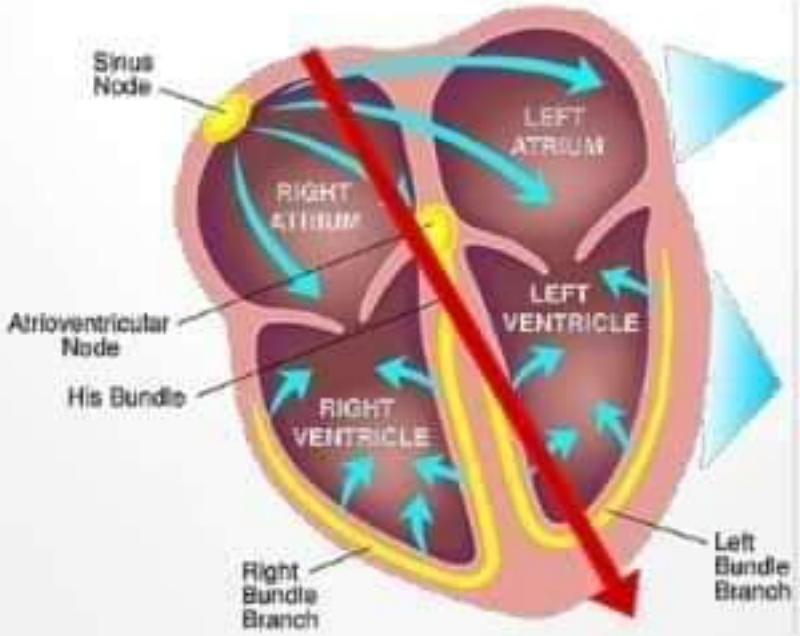
- Back-up pacemaker
- Intrinsic rate of 40 - 60 beats/minute.

Ventricular cells

- Back-up pacemaker
- Intrinsic rate of 20 - 45 beats/minute.

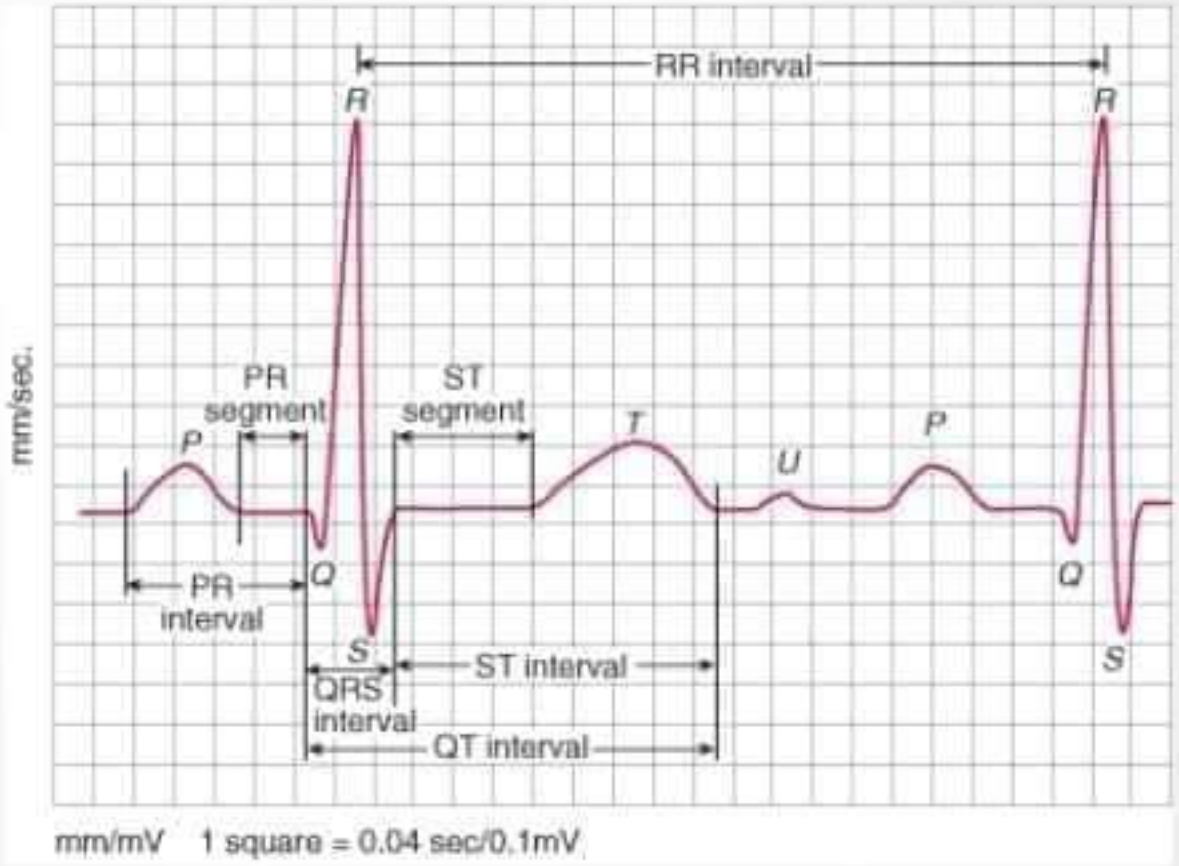
AXIS OF THE HEART

- The **electrical axis of the heart** is the mean direction of the action potentials traveling through the conductive system of the heart.



ECG COMPLEX

- Waveforms
  - P wave
  - QRS complex
  - T wave
  - U wave
- Segments
  - PR segment
  - ST segment
- Intervals
  - PR interval
  - QT interval
  - RR interval



HOW TO DO ELECTROCARDIOGRAPHY

1. Place the patient in a supine or semi-Fowler's position. If the patient cannot tolerate being flat, you can do the ECG in a more upright position.
2. Instruct the patient to place their arms down by their side and to relax their shoulders.
3. Make sure the patient's legs are uncrossed.
4. Remove any electrical devices, such as cell phones, away from the patient as they may interfere with the machine.
5. If you're getting artifact in the limb leads, try having the patient sit on top of their hands.
6. Causes of artifact: patient movement, loose/defective electrodes/apparatus, improper grounding.

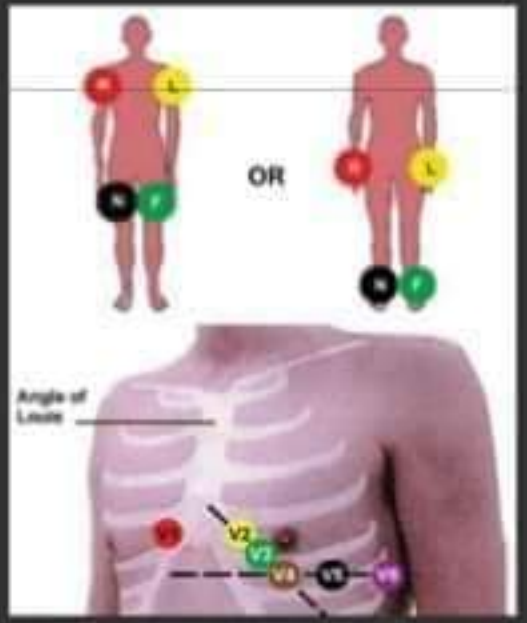
Patient, supine position

An ECG with artifacts.

Electrodes

Usually consist of a conducting gel, embedded in the middle of a self-adhesive pad onto which cables clip. Ten electrodes are used for a 12-lead ECG.

Placement of electrodes



The limb electrodes

RA - On the right arm, avoiding thick muscle
LA – On the left arm this time.
RL - On the right leg, lateral calf muscle
LL - On the left leg this time.

The 6 chest electrodes

V1 - Fourth intercostal space, right sternal border.
V2 - Fourth intercostal space, left sternal border.
V3 - Midway between V2 and V4.
V4 - Fifth intercostal space, left midclavicular line.
V5 - Level with V4, left anterior axillary line.
V6 - Level with V4, left mid axillary line.

PEOPLE USUALLY REFER THE ELECTRODES CABLES AS

LEADS

DUDE, THAT'S CONFUSING!

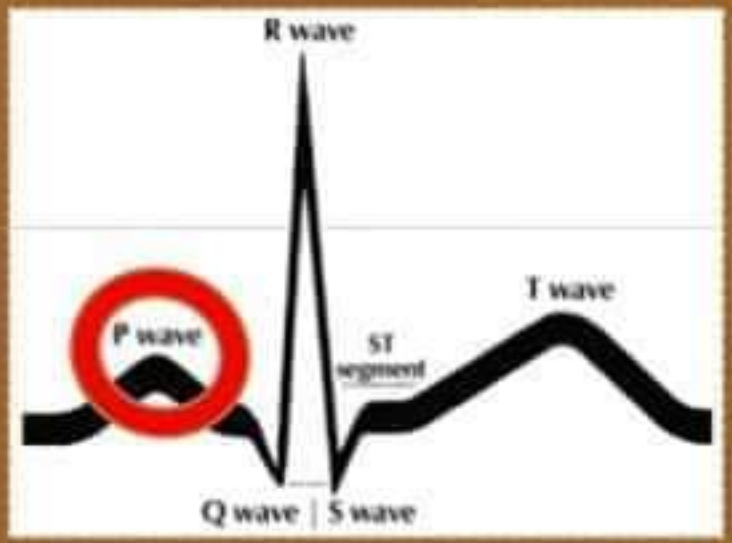
LEADS

should be correctly defined as the tracing of the voltage difference between the electrodes and is what is actually produced by the ECG recorder.

ECG Representation

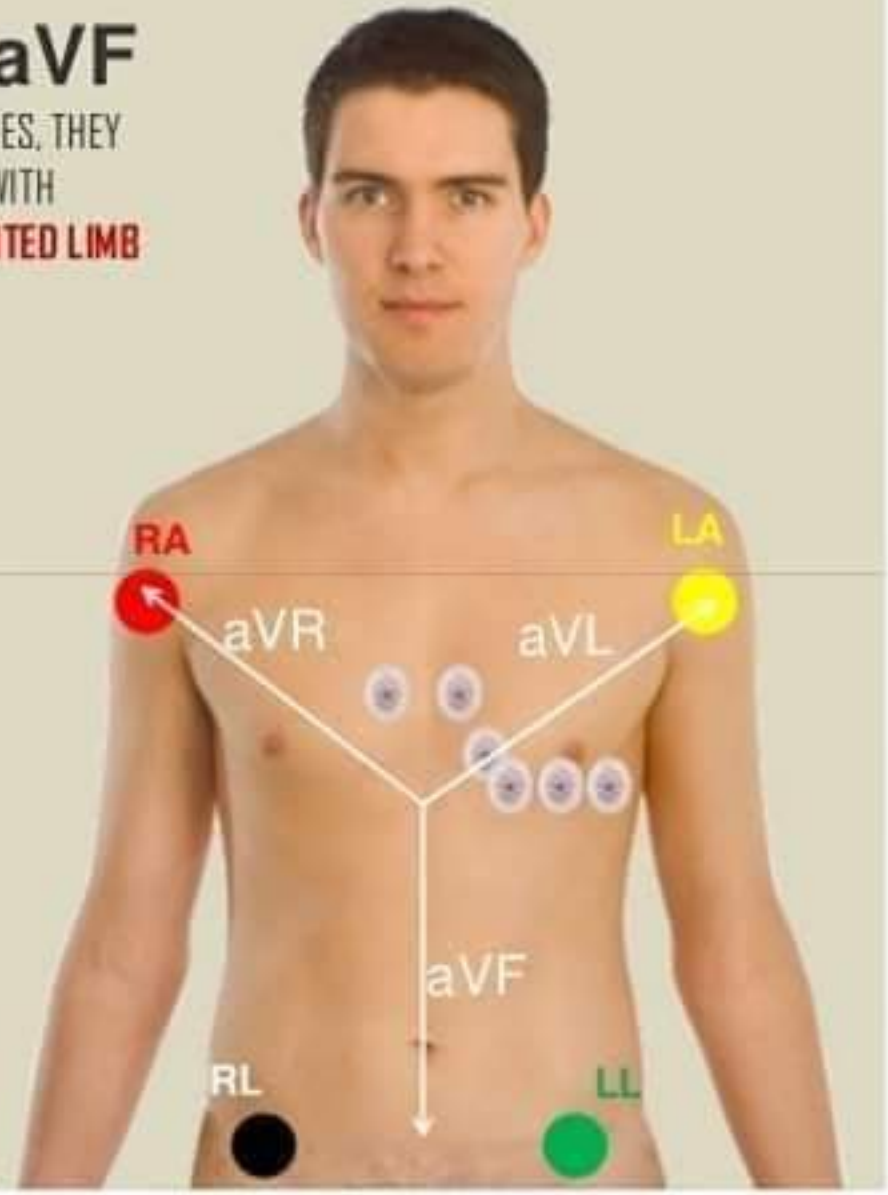
P wave represents Atrial depolarization

Vector is from SA node to AV node



LEADS aVR, aVL, aVF

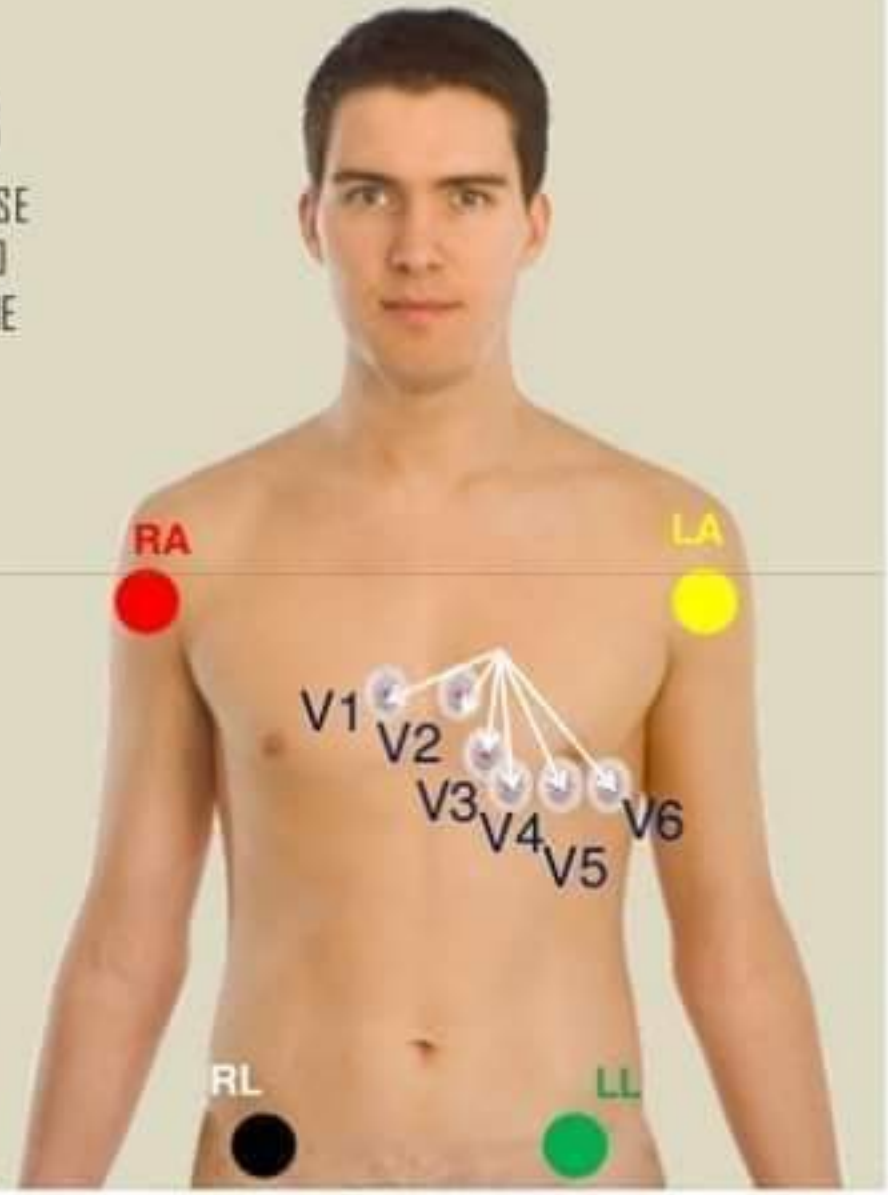
THEY ARE ALSO DERIVED FROM THE LIMB ELECTRODES, THEY MEASURE THE ELECTRIC POTENTIAL AT ONE POINT WITH RESPECT TO A NULL POINT. THEY ARE THE **AUGMENTED LIMB LEADS**

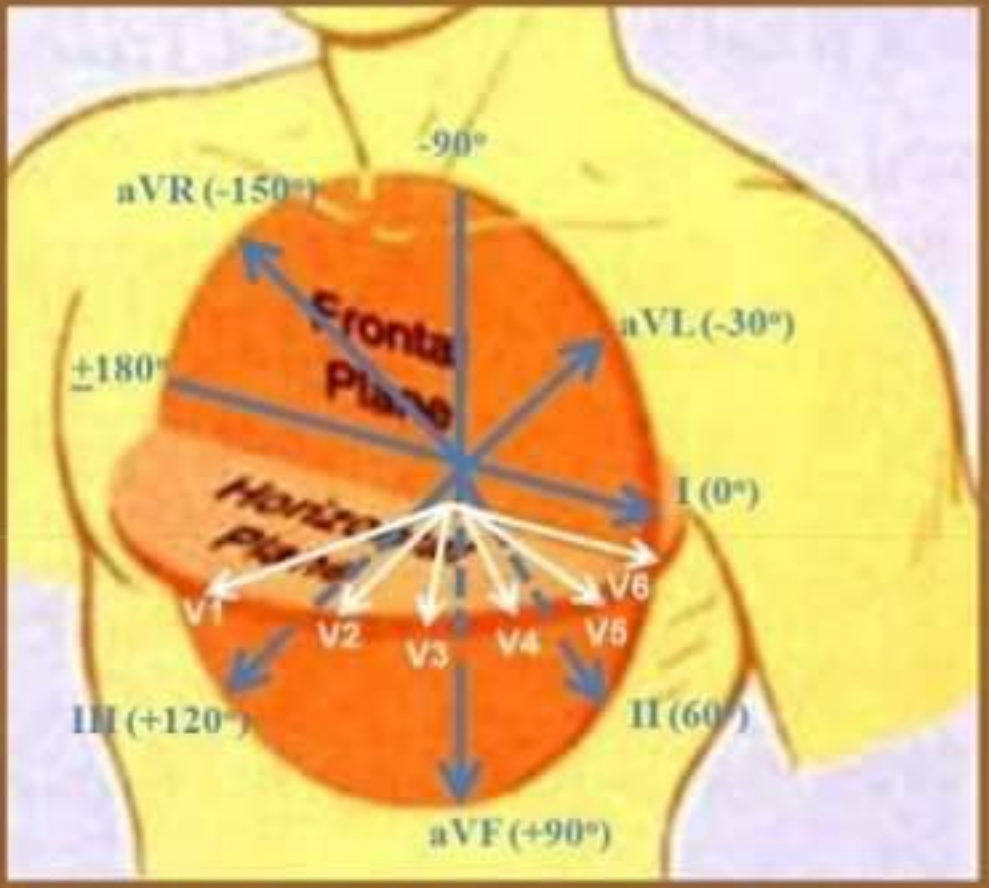


LEADS

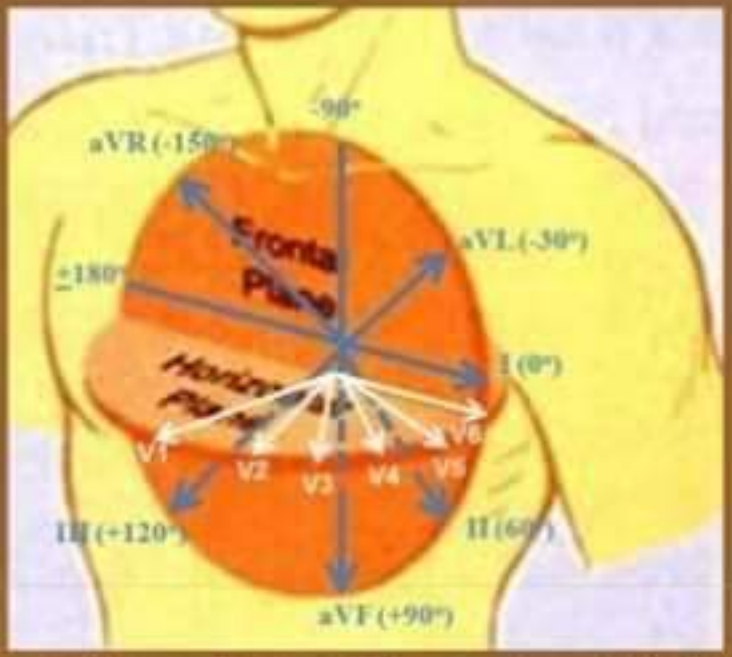
V1,V2,V3,V4,V5,V6

THEY ARE PLACED DIRECTLY ON THE CHEST. BECAUSE OF THEIR CLOSE PROXIMITY OF THE HEART, THEY DO NOT REQUIRE AUGMENTATION. THEY ARE CALLED THE **PRECORDIAL LEADS**





These leads help to determine heart's electrical axis. The limb leads and the augmented limb leads form the frontal plane. The precordial leads form the horizontal plane.



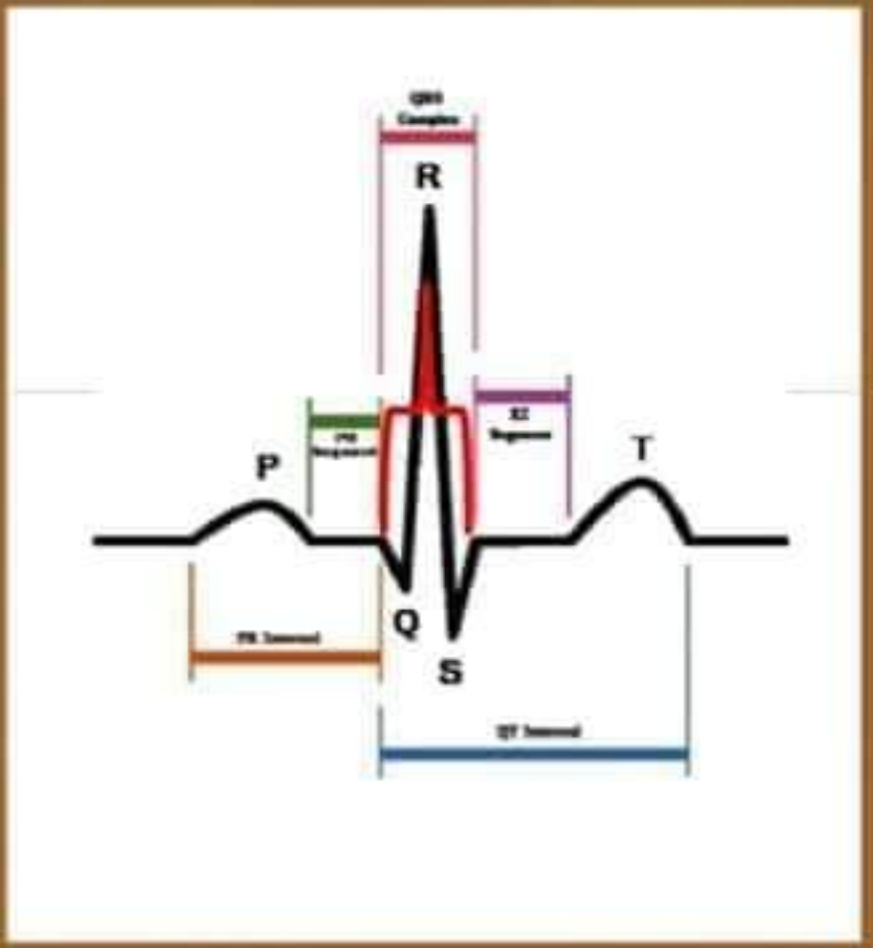
The Different Views Reflect The Angles At Which LEADS "LOOK" At The Heart And The Direction Of The Heart's Electrical Depolarization.

Leads	Anatomical representation of the heart
V1, V2, V3, V4	Anterior
I, aVL, V5, V6	left lateral
II, III, aVF	inferior
aVR, V1	Right atrium

ECG Representation

QRS Complex
represents Ventricular depolarization

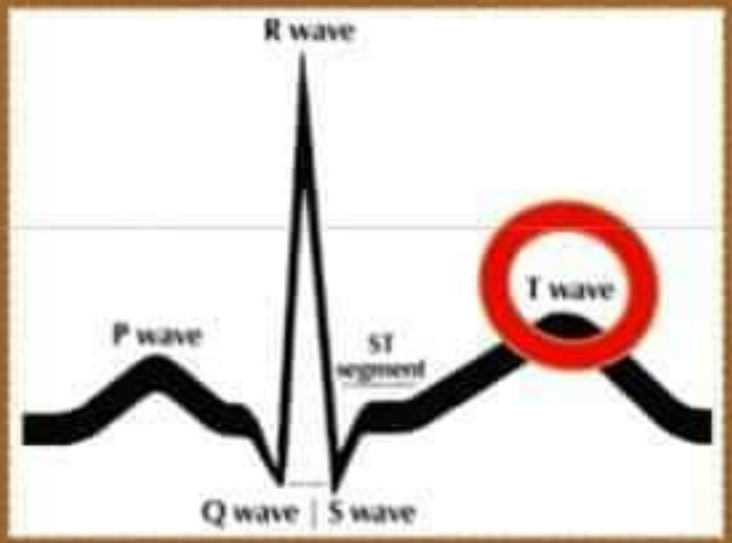
Normal
0.06 to 0.10 seconds



ECG Representation

T wave represents Ventricular repolarization

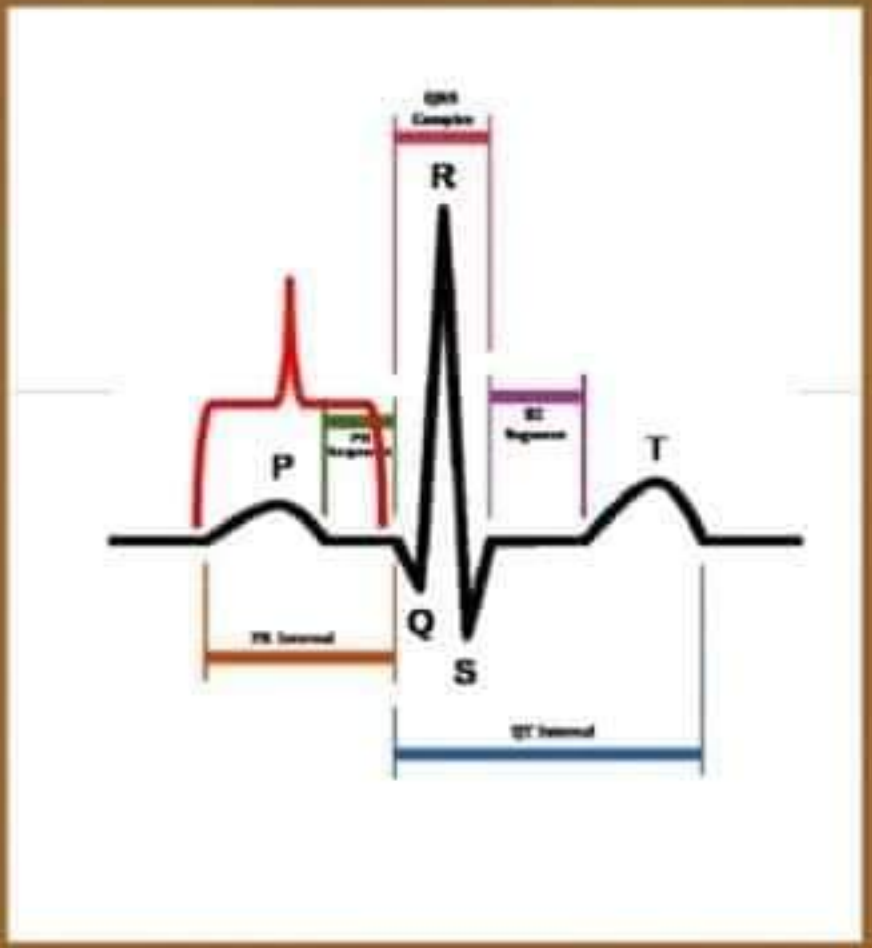
Vector is from SA node to AV node



ECG Representation

PR Interval
0.12 – 0.20 seconds

Time for electrical impulse takes to travel from sinus node through the AV node and entering the ventricles

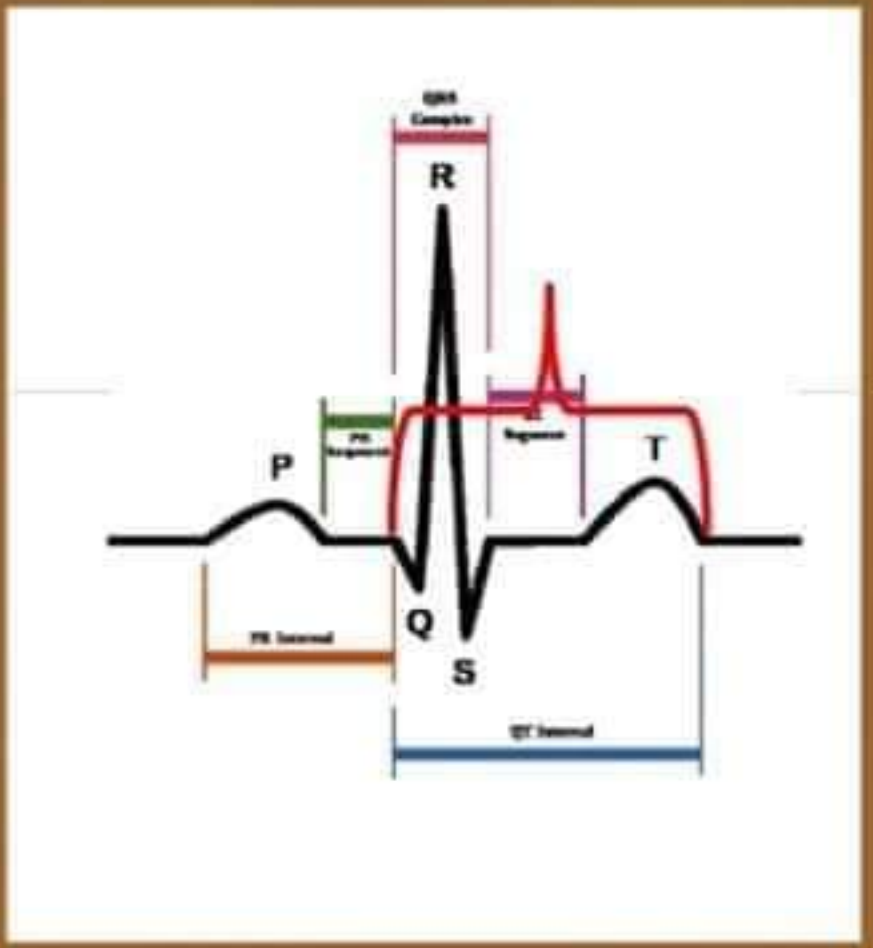


ECG Representation

QT Interval

0.32 – 0.40 seconds

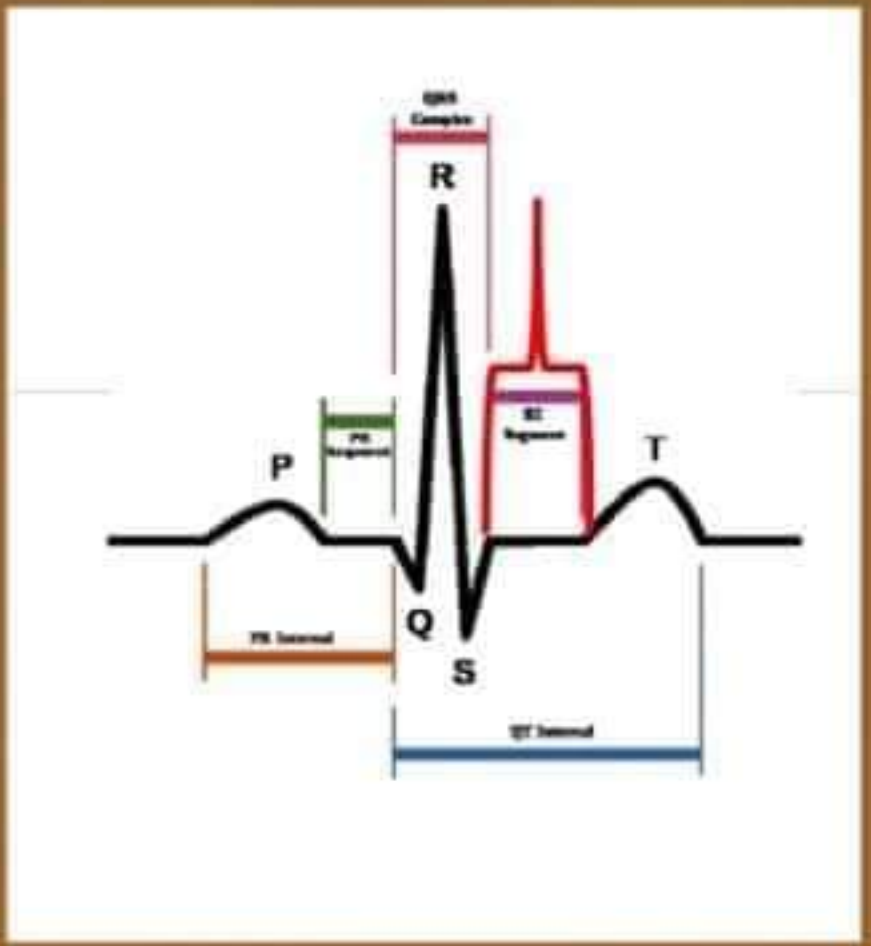
A prolonged QT interval is a risk factor for ventrial tachyarrhythmias and sudden death



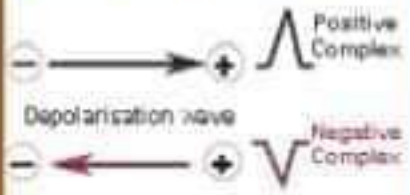
ECG Representation

ST segment represents the early phase of ventricular repolarization

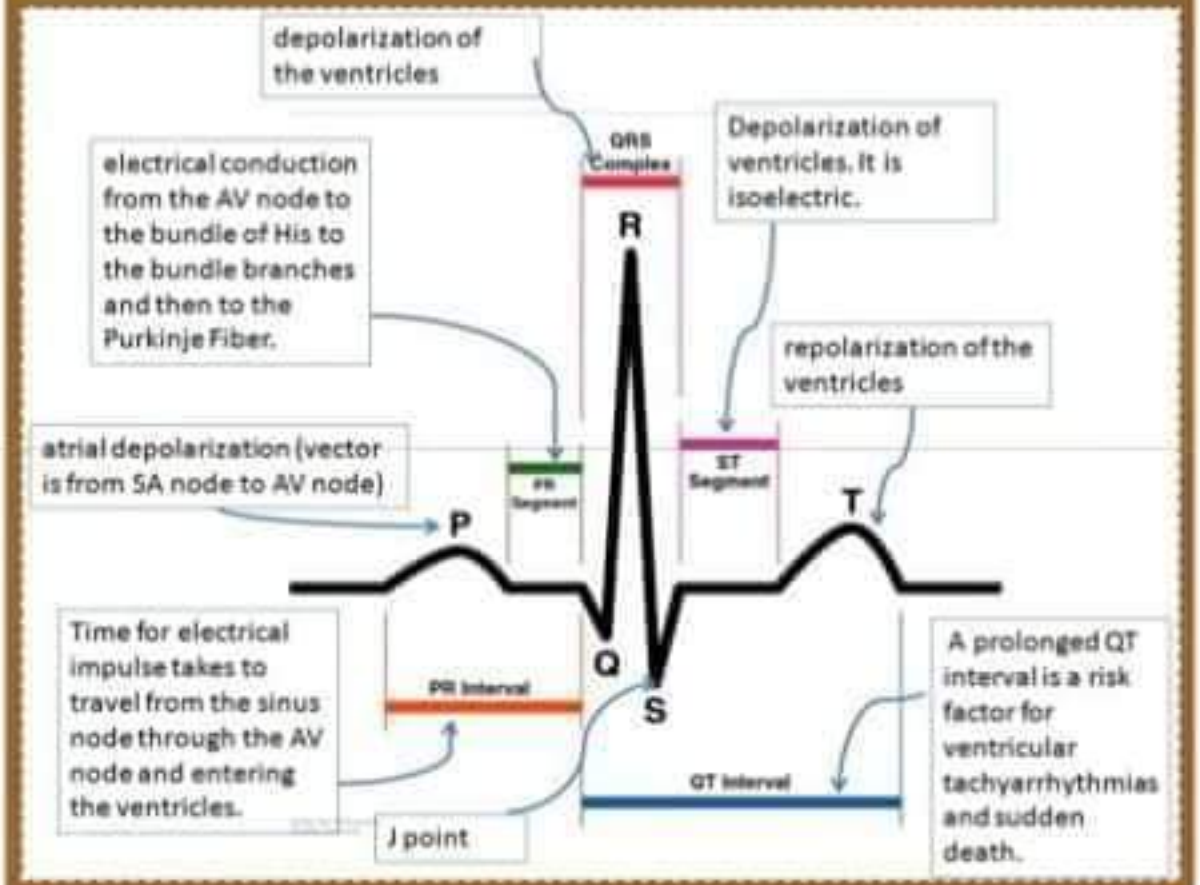
It is Isoelectric



Understanding ECG Waveform

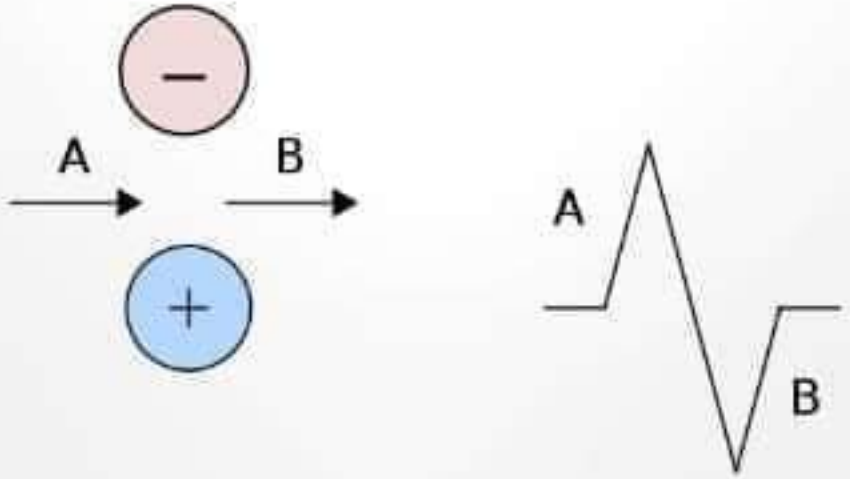


If a wavefront of depolarization travels towards the positive electrode, a positive-going deflection will result. If the waveform travels away from the positive electrode, a negative going deflection will be seen.

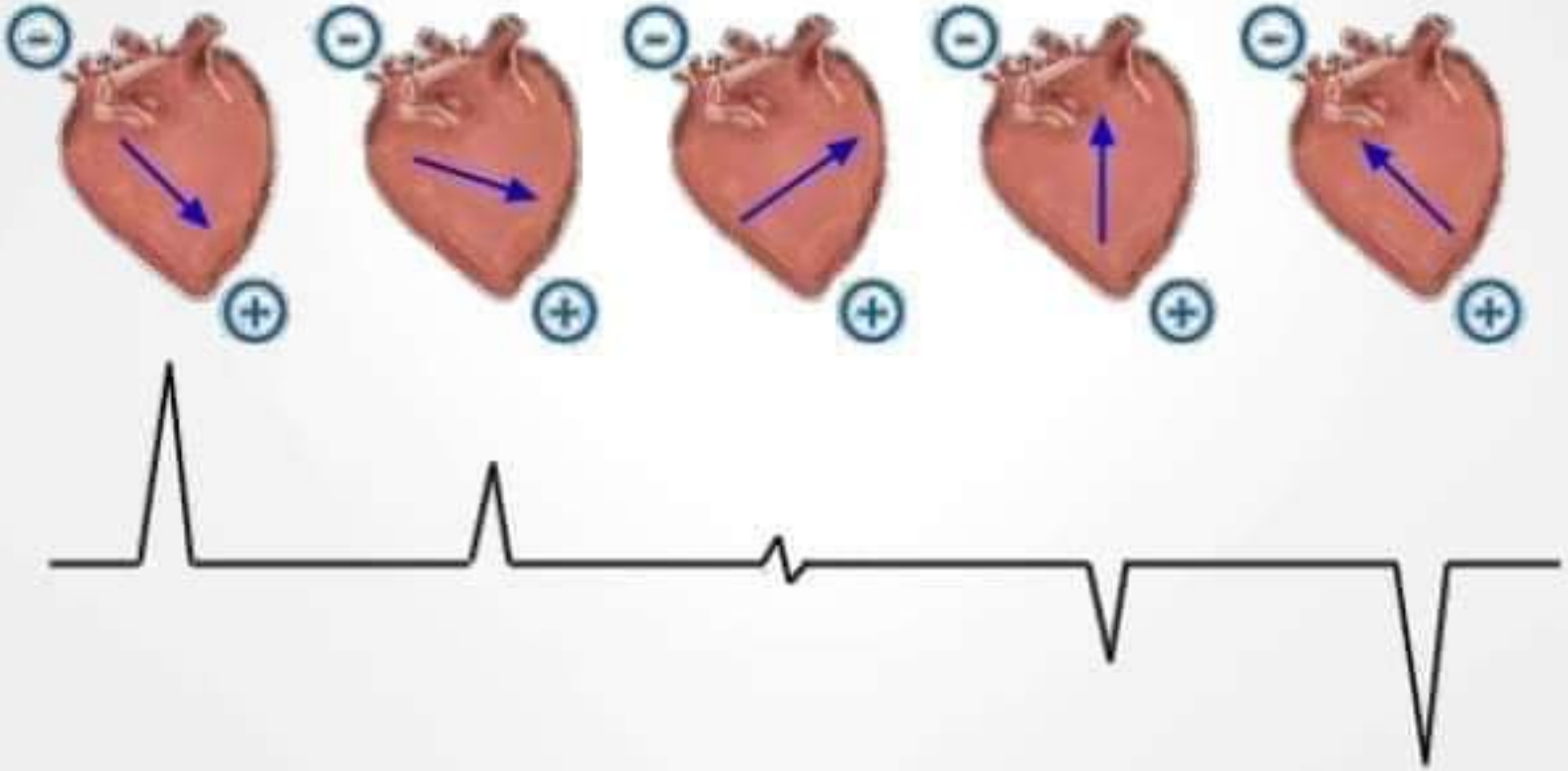


ELECTROMAGNETICS

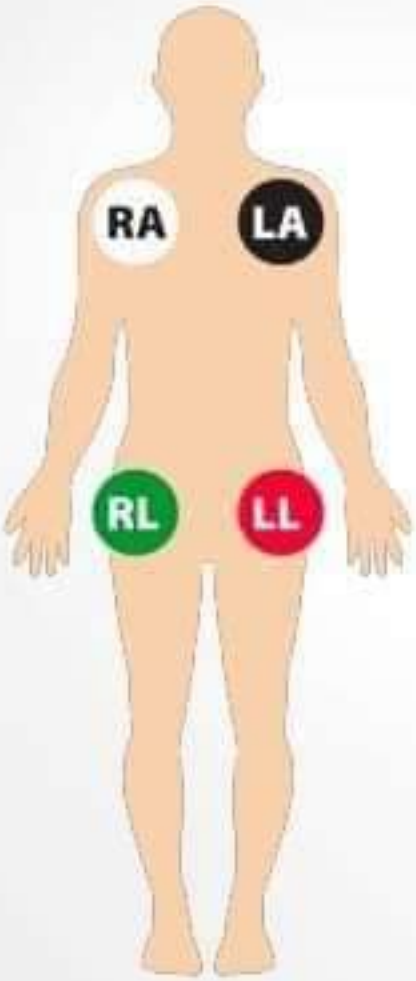
- If direction of conduction is at right angle to the positive electrode it will produce positive deflection (depolarization) and then negative deflection (repolarization).



ELECTROMAGNETICS



LIMB ELECTRODES



RA Right Arm

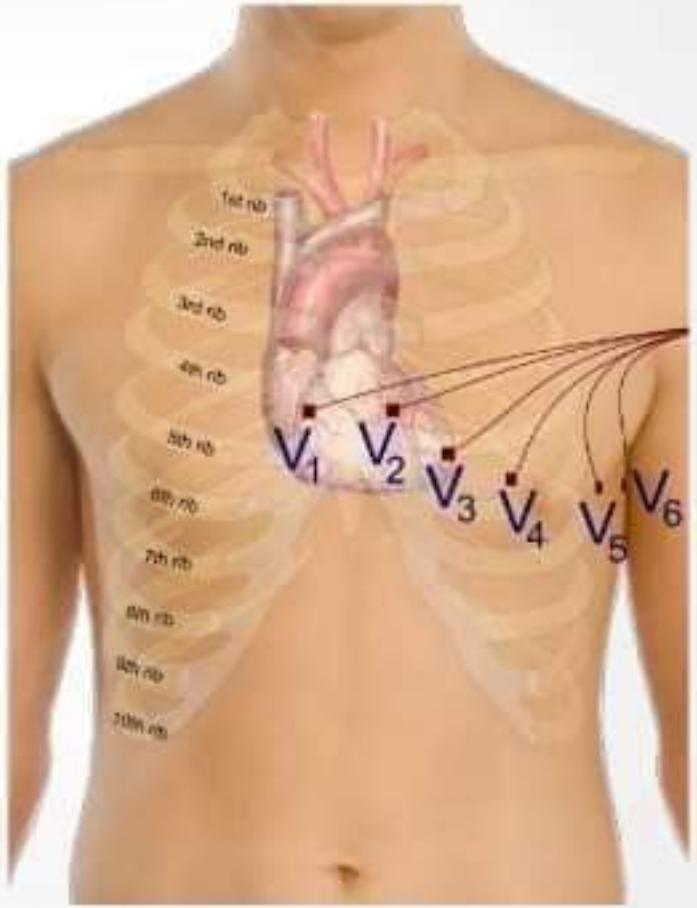
LA Left Arm

LL Left Leg

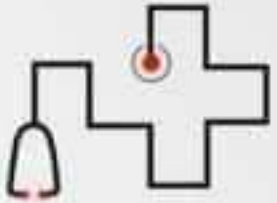
RL Right Leg

CHEST ELECTRODES

Chest Electrode Placement	
V1	4th ICS, right of sternum
V2	4th ICS, left of sternum
V3	Between V2 and V4
V4	5th ICS, in left mid clavicular line
V5	Same height as V4, in left anterior axillary line
V6	Same height as V4, in left mid axillary line



REPORTING AN ECG



- Estimated heart rate
- Comment on the rhythm
- Comment on the axis
- Comment on:
  - P wave morphology
  - PR segment
  - QRS morphology
  - ST segment
  - T wave morphology
  - QT interval
- Compare with a previous ECG
- Conclusion

The best way to interpret an ECG is to do it step-by-step

Rate
Rhythm
Cardiac Axis
P – wave
PR - interval
QRS Complex
ST Segment
QT interval (Include T and U wave)
Other ECG signs

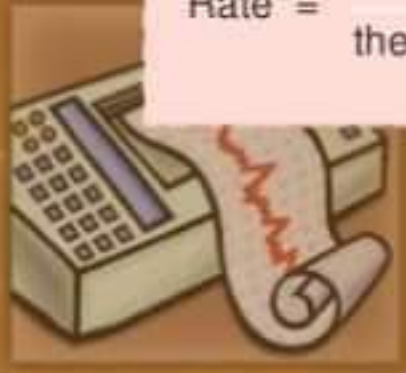
CALCULATING RATE

As a general interpretation, look at **lead II** at the bottom part of the ECG strip. This lead is the **rhythm strip** which shows the rhythm for the whole time the ECG is recorded. Look at the number of square between one R-R interval. To calculate rate, use any of the following formulas:

$$\text{Rate} = \frac{300}{\text{the number of } \textbf{BIG SQUARE} \text{ between R-R interval}}$$

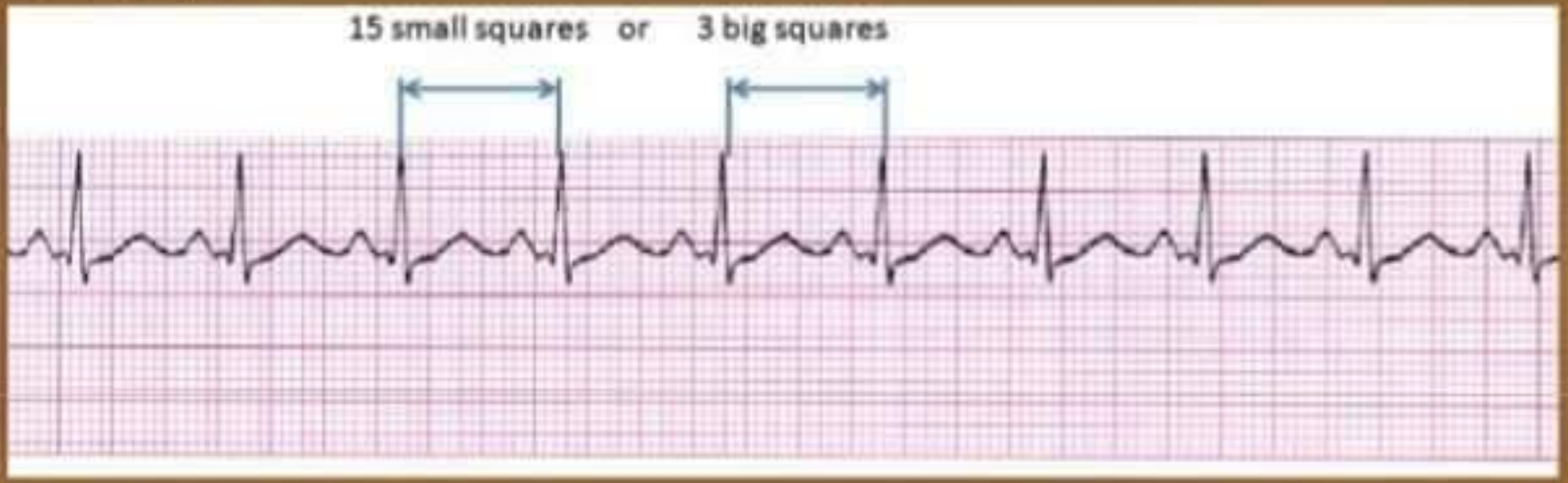
OR

$$\text{Rate} = \frac{1500}{\text{the number of } \textbf{SMALL SQUARE} \text{ between R-R interval}}$$



CALCULATING RATE

For example:



$$\text{Rate} = \frac{300}{3} \quad \text{or} \quad \text{Rate} = \frac{1500}{15}$$

Rate = **100** beats per minute

CALCULATING RATE

If you think that the **rhythm is not regular**, count the number of electrical beats in a 6-second strip and multiply that number by 10.(Note that some ECG strips have 3 seconds and 6 seconds marks) Example below:

There are 8 waves in this 6-seconds strip.

Rate = (Number of waves in 6-second strips) x 10
= 8 x 10
= **80** bpm

CALCULATING RATE

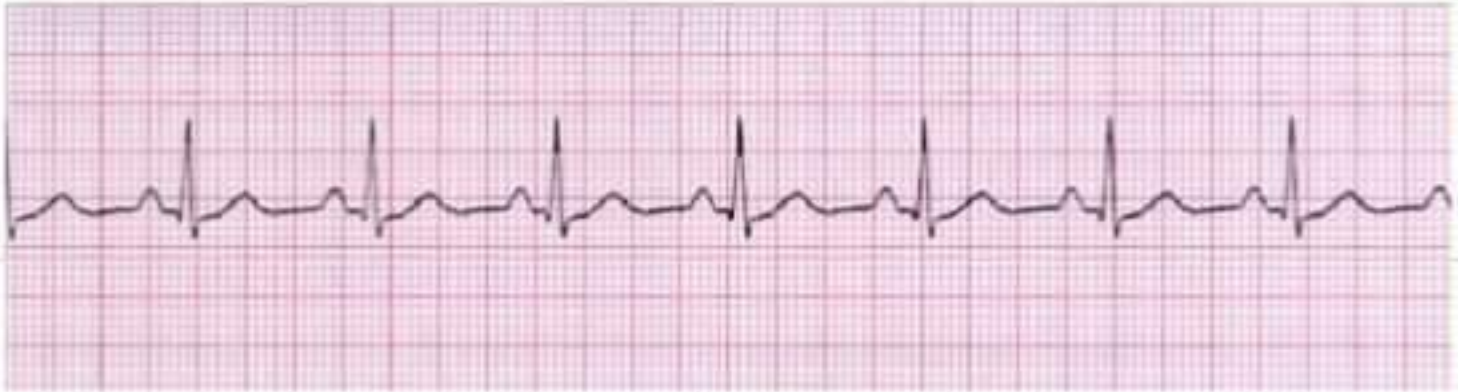
Interpretation	bpm	Causes
Normal	60-99	-
Bradycardia	<60	hypothermia, increased vagal tone (due to vagal stimulation or e.g. drugs), atheletes (fit people) hypothyroidism, beta blockade, marked intracranial hypertension, obstructive jaundice, and even in uraemia, structural SA node disease, or ischaemia.
Tachycardia	>100	Any cause of adrenergic stimulation (including pain); thyrotoxicosis; hypovolaemia; vagolytic drugs (e.g. atropine) anaemia, pregnancy; vasodilator drugs, including many hypotensive agents; FEVER, myocarditis

RHYTHM

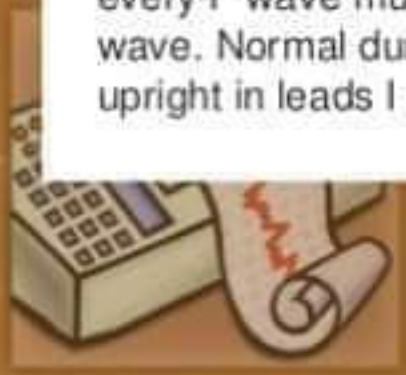
Look at p waves and their relationship to QRS complexes.
Lead II is commonly used
Regular or irregular?
If in doubt, use a **paper strip** to map out consecutive beats and see whether the rate is the same further along the ECG.
Measure ventricular rhythm by measuring the R-R interval and atrial rhythm by measuring P-P interval.

RHYTHM

Normal Sinus Rhythm

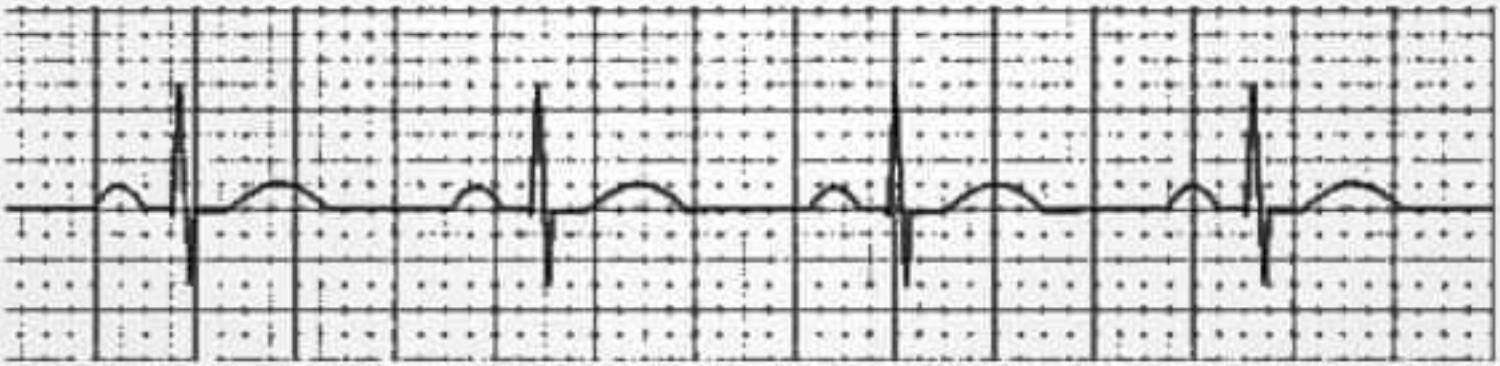


ECG rhythm characterized by a usual rate of anywhere between 60-99 bpm, every P wave must be followed by a QRS and every QRS is preceded by P wave. Normal duration of PR interval is 3-5 small squares. The P wave is upright in leads I and II



NORMAL SINUS RHYTHM

- Normal heart rate
- Regular rhythm
- P waves should be sinus
- P wave is round and upward in lead I & II
- Each QRS is preceded by a P wave
- The PR interval should remain constant
- QRS complexes should be narrow



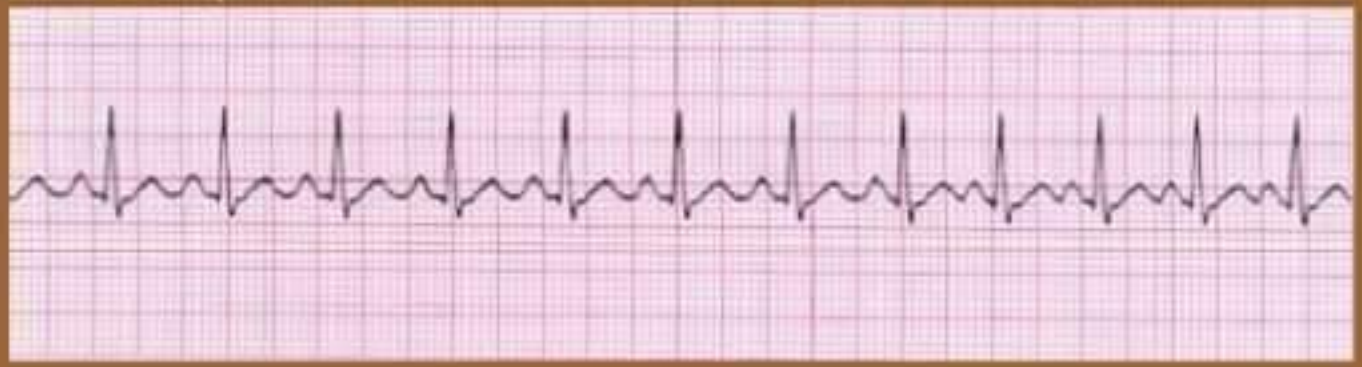
RHYTHM

Sinus Bradycardia

Rate < 60bpm, otherwise normal

RHYTHM

Sinus Tachycardia



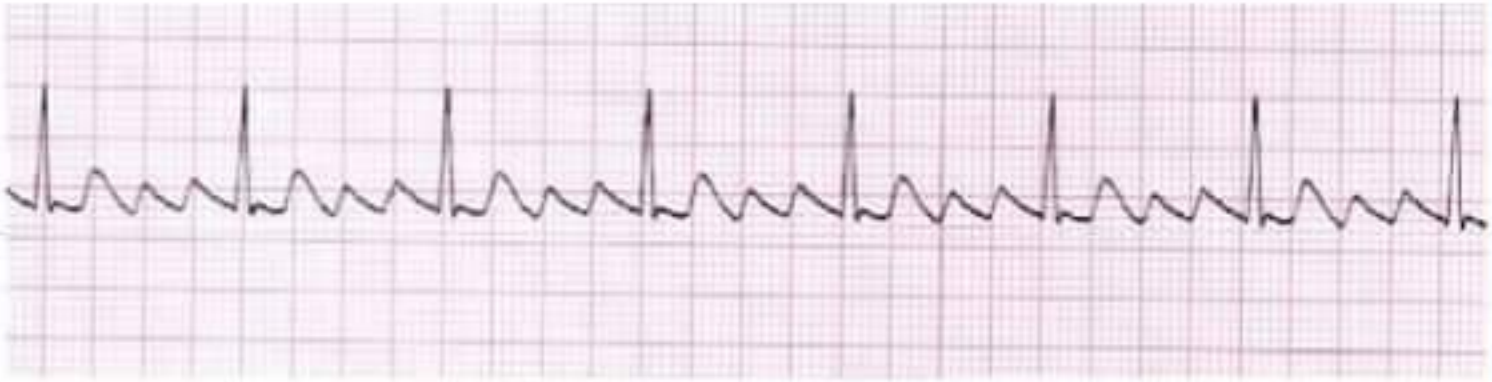
Rate >100bpm, otherwise, normal

RHYTHM

Atrial Fibrillation

A-fib is the most common cardiac arrhythmia involving atria.
Rate= ~150bpm, irregularly irregular, baseline irregularity, no visible p waves, QRS occur irregularly with its length usually < 0.12s

Atrial Flutter



Atrial Rate=~300bpm, similar to A-fib, but have flutter waves, ECG baseline adapts 'saw-toothed' appearance'. Occurs with atrioventricular block (fixed degree), eg: 3 flutters to 1 QRS complex:

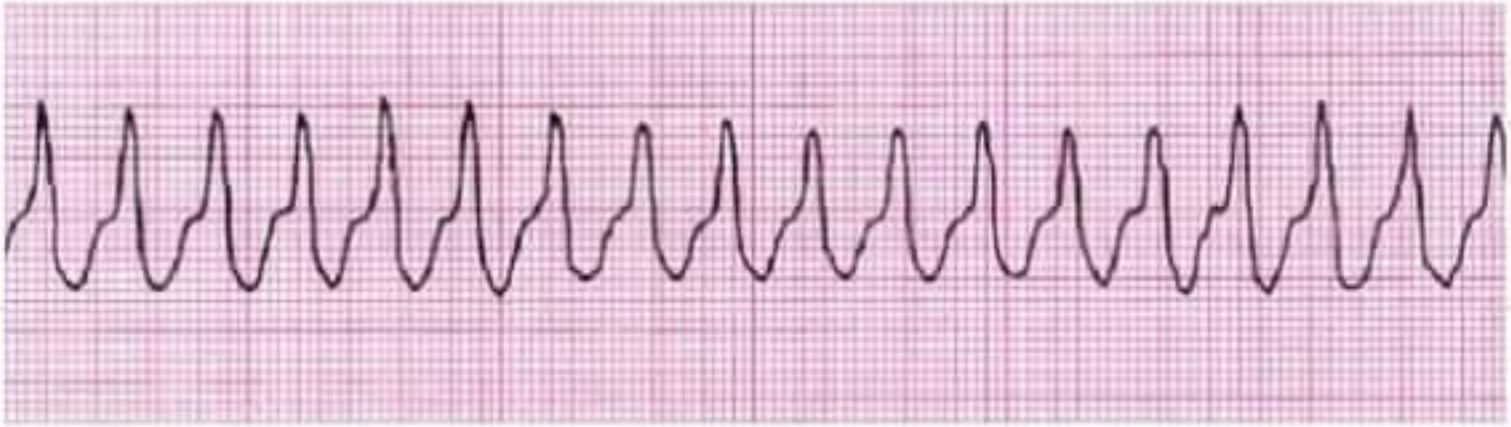
RHYTHM

Ventricular Fibrillation

A severely abnormal heart rhythm (arrhythmia) that can be life-threatening.
Emergency- requires Basic Life Support
Rate cannot be discerned, rhythm unorganized

RHYTHM

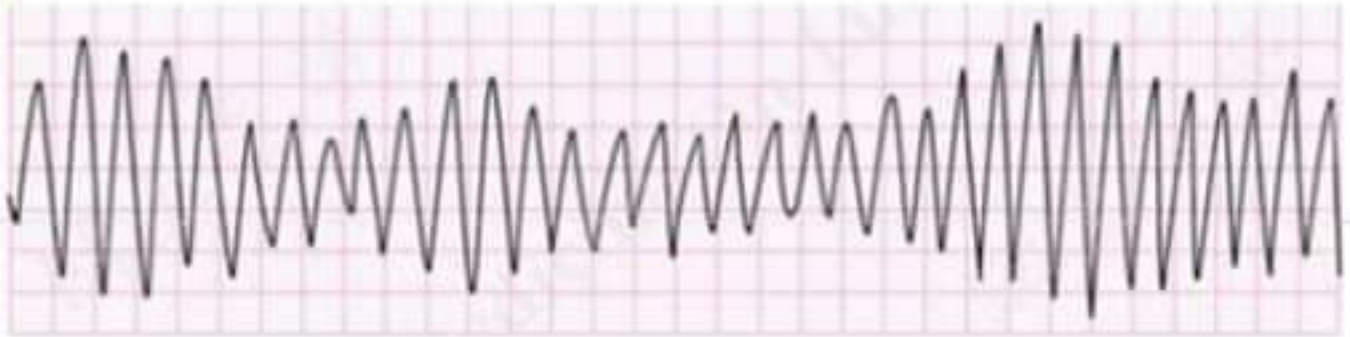
Ventricular tachycardia



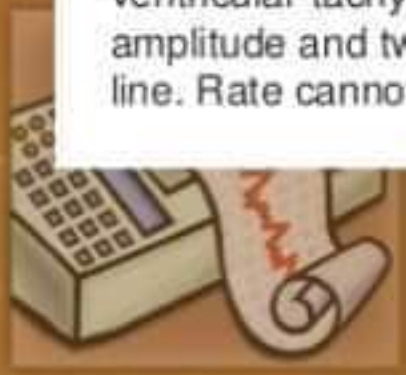
fast heart rhythm, that originates in one of the ventricles- potentially life-threatening arrhythmia because it may lead to ventricular fibrillation, asystole, and sudden death.
Rate=100-250bpm

RHYTHM

Torsades de Pointes

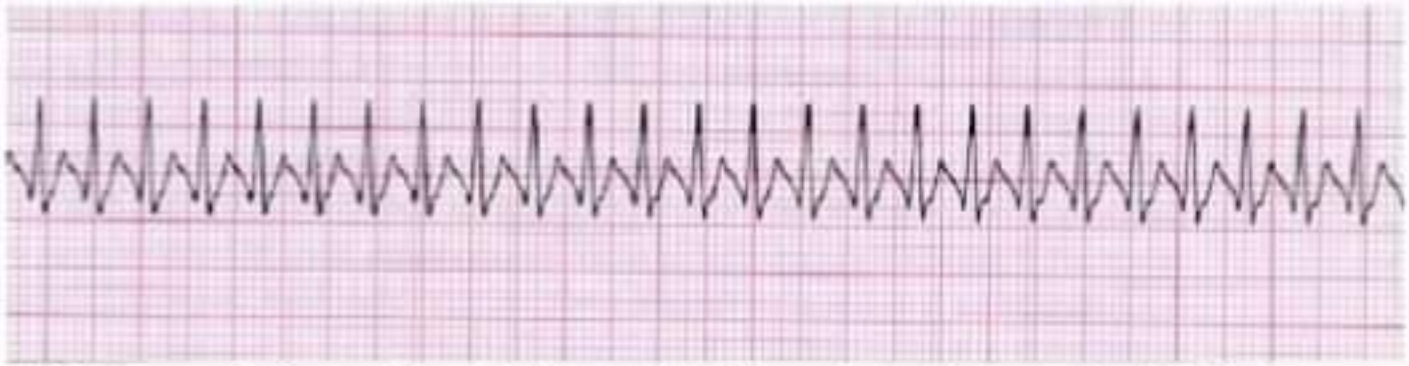


literally meaning twisting of points, is a distinctive form of polymorphic ventricular tachycardia characterized by a gradual change in the amplitude and twisting of the QRS complexes around the isoelectric line. Rate cannot be determined.



RHYTHM

Supraventricular Tachycardia



SVT is any tachycardiac rhythm originating above the ventricular tissue.
Atrial and ventricular rate= 150-250bpm
Regular rhythm, p is usually not discernable.

*Types:

- •Sinoatrial node reentrant tachycardia (SANRT)
- •Ectopic (unifocal) atrial tachycardia (EAT)
- •Multifocal atrial tachycardia (MAT)
- •A-fib or A flutter with rapid ventricular response. Without rapid ventricular response both usually not classified as SVT
- •AV nodal reentrant tachycardia (AVNRT)
- •Permanent (or persistent) junctional reciprocating tachycardia (PJRT)
- •AV reentrant tachycardia (AVRT)