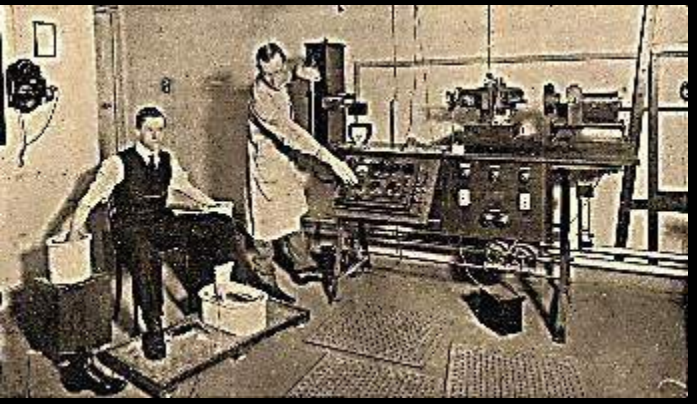
ECG – A simple Review



Dato-Wira' Prof Dr L R Chandran DGMK DSDK SDK BCK

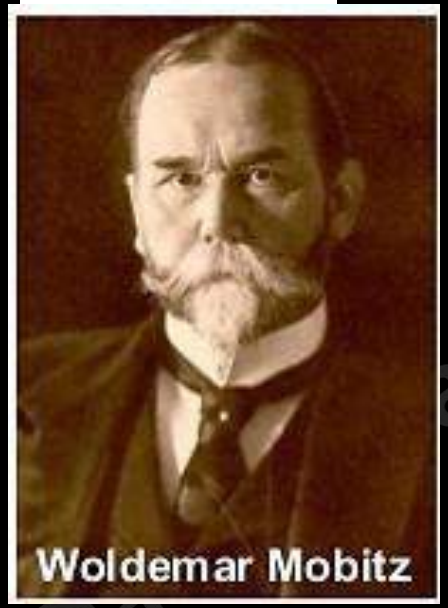
MBBS(Monash) MRCP(UK) FRCP(Edin) FRCP(Lond) FRCP(Glasg)

Fellow of the Academy of Medicine Malaysia (FAMM)

Council Member

College of Physicians of Malaysia

1924



Willem Einthoven

Karel Fredrik Wenckebach 1899

1899

Karel Frederik Wenckebach

publishes a paper
"On the analysis of irregular pulses"
describing impairment of AV conduction leading to progressive lengthening and blockage of AV conduction in frogs.

This will later be called
Wenckebach block (Mobitz type I) or
Wenckebach phenomenon. [till TODAY]

1924

Willem Einthoven wins the Nobel prize for inventing the ElectroCardioGraph.

Willem Einthoven 1924

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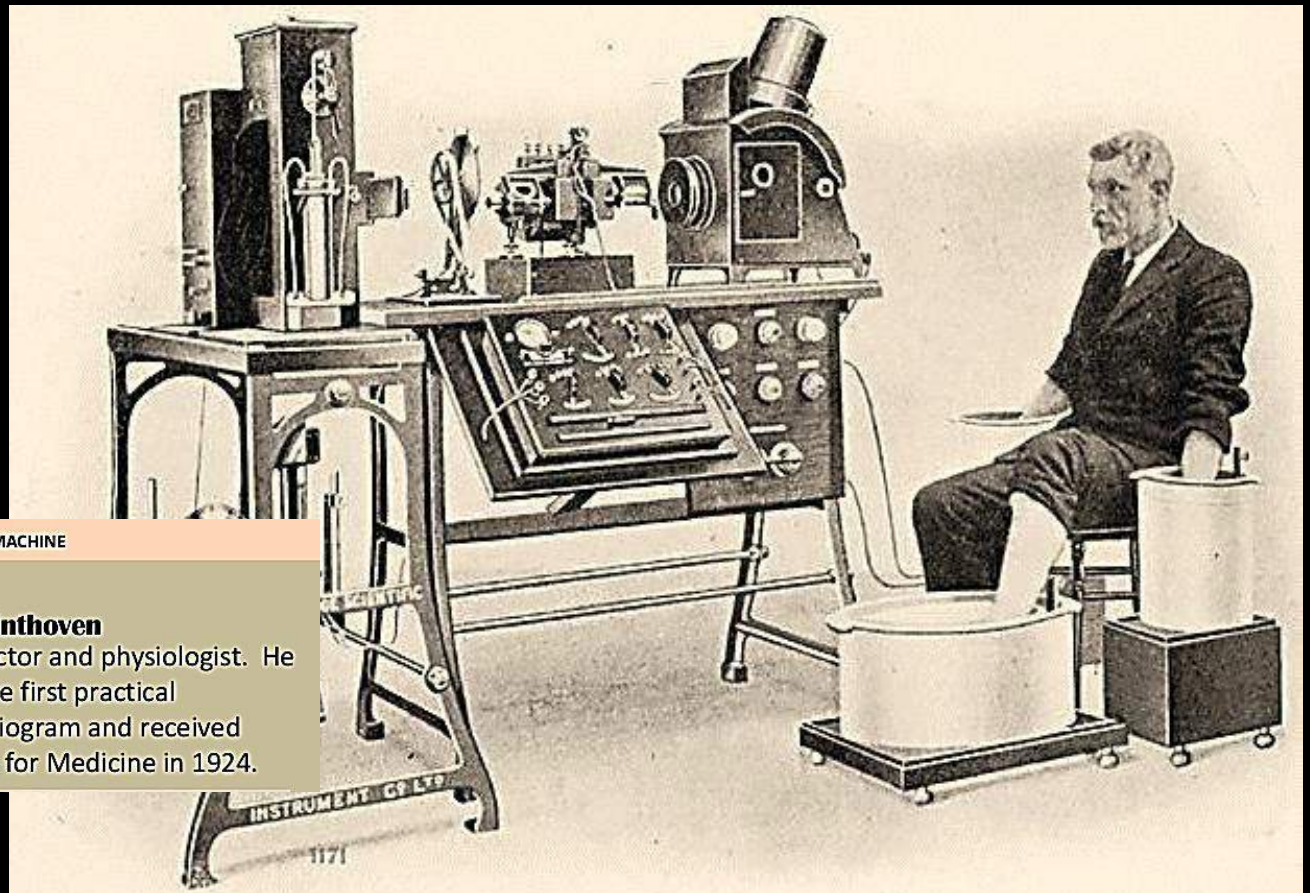
THE HISTORY OF ECG MACHINE

1903

Willem Einthoven

A Dutch doctor and physiologist. He invented the first practical electrocardiogram and received Nobel Prize for Medicine in 1924.

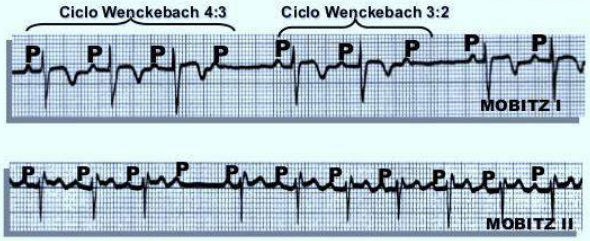


PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES A
ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF
SALT SOLUTION

1924

Woldemar Mobitz publica su clasificación de los bloqueos AV de segundo grado (Mobitz tipo I y tipo II) fundamentada en el ECG y en el pulso yugular, éste observado antes de la era del ECG por Wenckebach[1]. Él menciona que el tipo I era de carácter fisiológico y el tipo II causado por una severa enfermedad infranodal del sistema hisiano.


Woldemar Mobitz

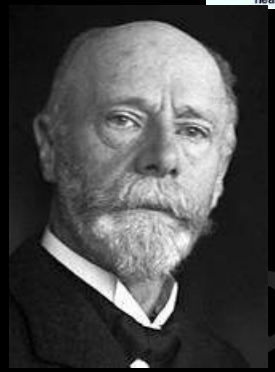


1. Mobitz W. Uber die unvollstandige Storung der Erregungsuberleitung zwischen Vorhof und Kammer des menschlichen Herzens. (Concerning partial block of conduction between the atria and ventricles of the human heart). Z Ges Exp Med 1924;41:180-237.

1924 Willem Einthoven wins the Nobel prize for inventing the electrocardiograph.

1924 *Woldemar Mobitz publishes his classification of heart blocks (Mobitz type I and type II) based on the electrocardiogram and jugular venous pulse waveform findings in patients with second degree heart block.*

Mobitz W. Uber die unvollstandige Storung der Erregungsuberleitung zwischen Vorhof und Kammer des menschlichen Herzens. (Concerning partial block of conduction between the atria and ventricles of the human heart). Z Ges Exp Med 1924;41:180-237.



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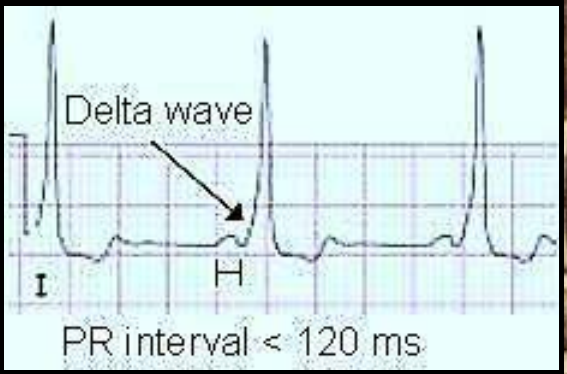
1899

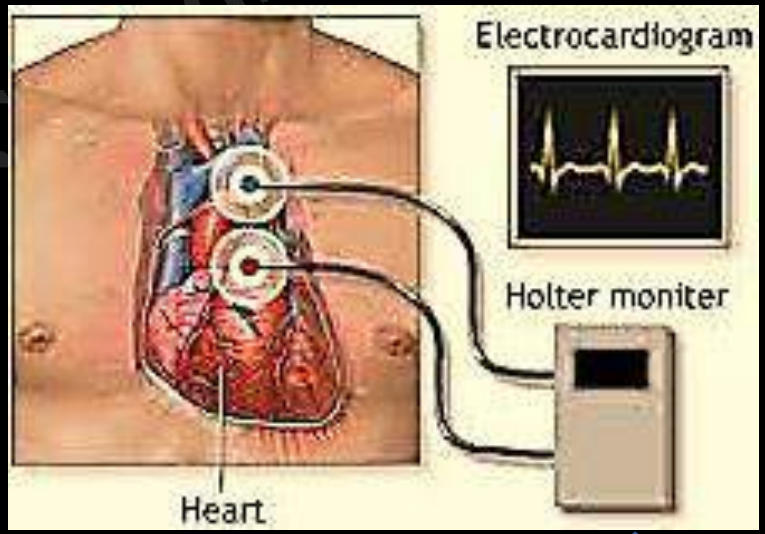


Wolff
Parkinson
White
Syndrome

Louis Wolff, Sir John Parkinson and Paul Dudley White, who discovered the phenomenon that later would be called the WPW syndrome. ---- **1930**

Jeff Holter
1947

Figure. Jeff Holter with his original 38-kg radio-electrocardiograph recording device in 1947.



Holter Machine

The MALAYSIAN Scene

- Commonest cause of deaths this Century–
  Cardiovascular / Cerebrovascular
- Commonest NON Infectious Diseases *HPTN*
  [43% above 30 years] & DM [16.2%]
- Control of HPTN 26 % DM ~ 10%

Usefulness of ECGs

☺ Best to Diagnose Myocardial Infarctions / Ischaemia

☺ Best to Diagnose RHYTHM disturbances – also Brady & Tachy ARRHYTHMIAs

☺ Reasonably Useful for Chamber Enlargements- Atria, Ventricles

☺ NOT useful for Heart Failure / PUMP problems

Usefulness of ECGs

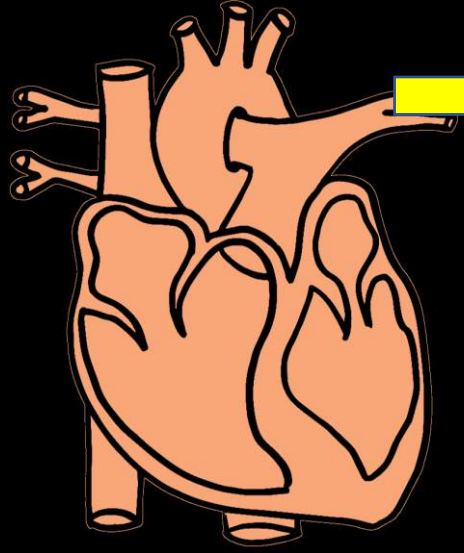
☺ INDEPENDENT of 'OPERATOR'

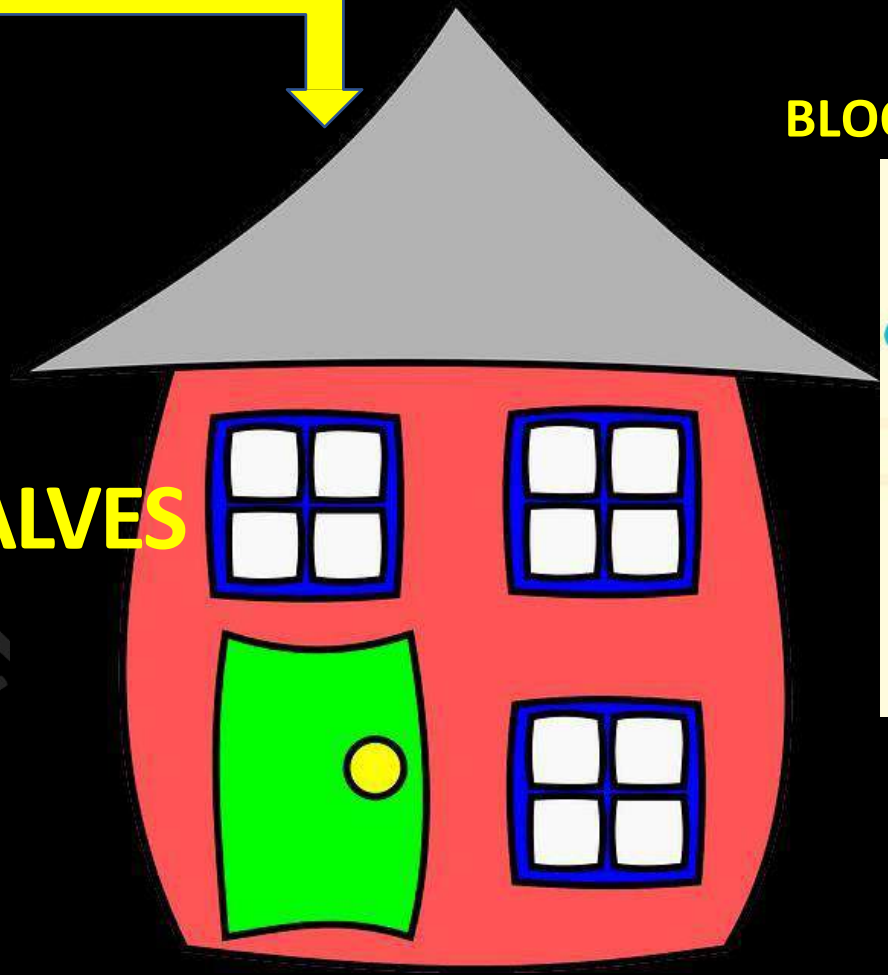
☺ EASILY available almost ANYWHERE

☺ Result can be

REPEATED

REPRODUCIBLE





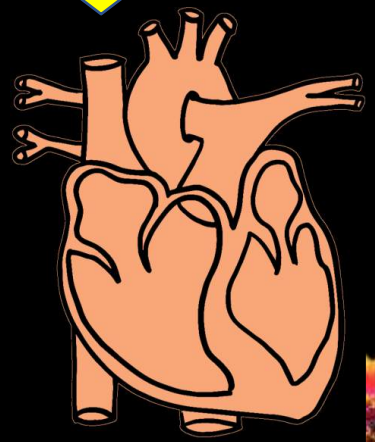
VALVES

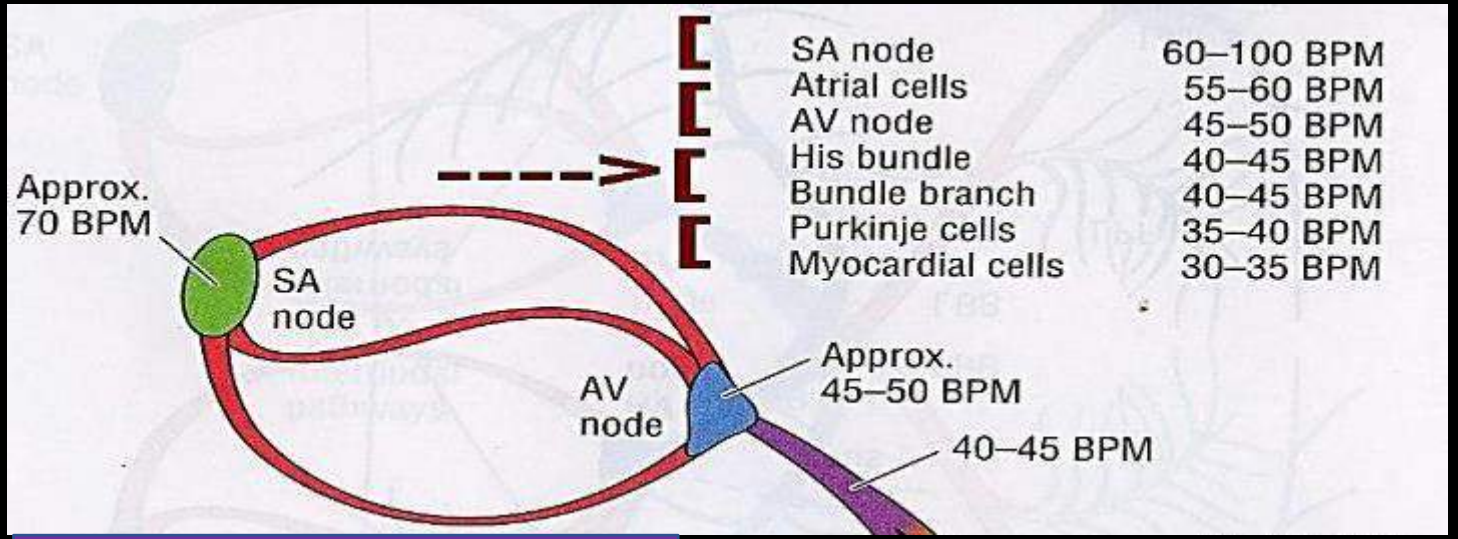
BLOOD -Circulation

Conduction System

BLOOD -Circulation

VALVES





Conducting System of the HEART

→ *'OWN'*
→ *'intrinsic'*
→ *CONDUCTION speeds*

Heart RATE:- **60 /min**

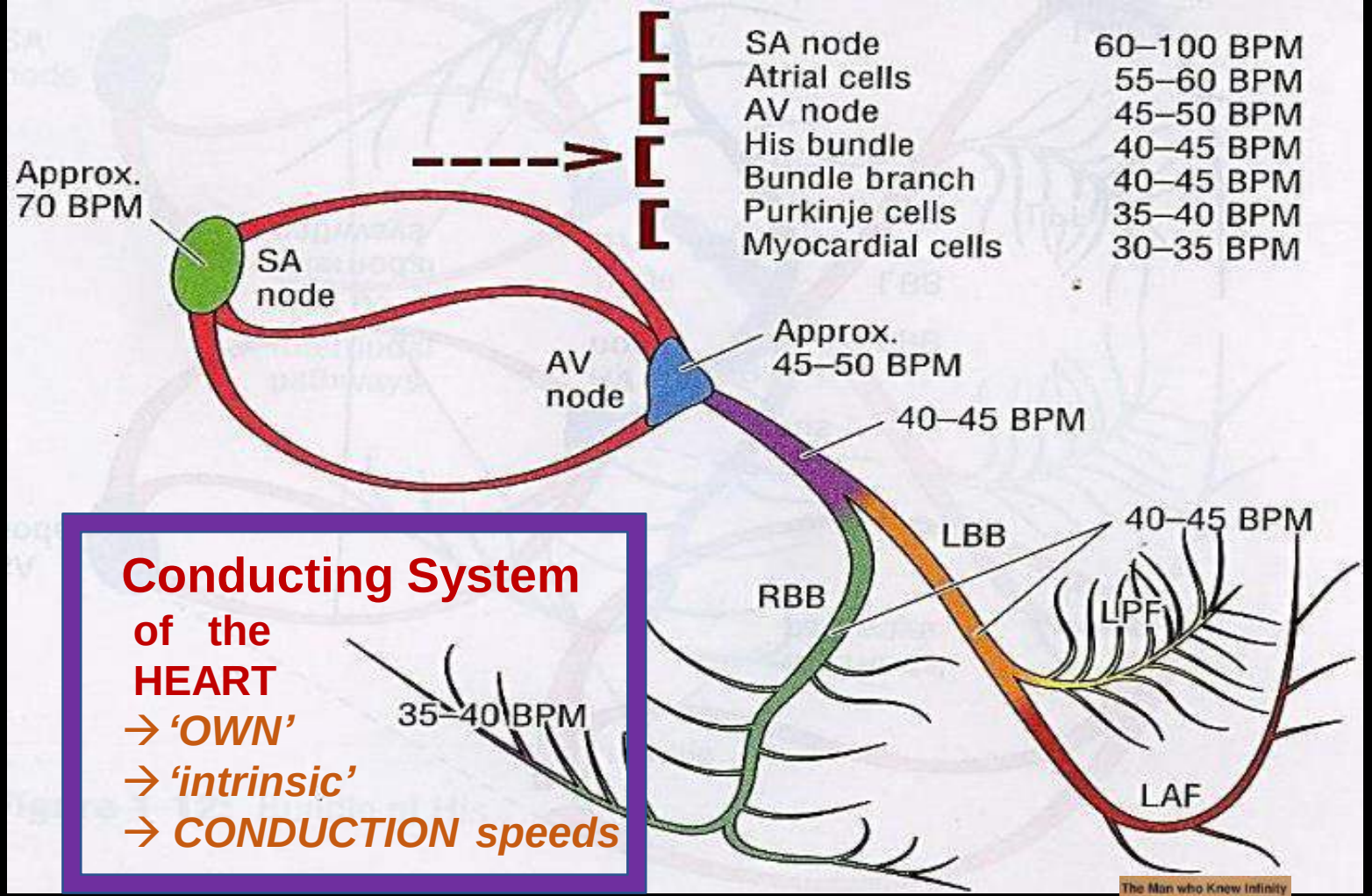
= **3600** / hour

= ~ **80, 000 / 24 hours**

In a 70 year old man

➔ **Has beaten 2 BILLION times**

➔ **[non-stop]**



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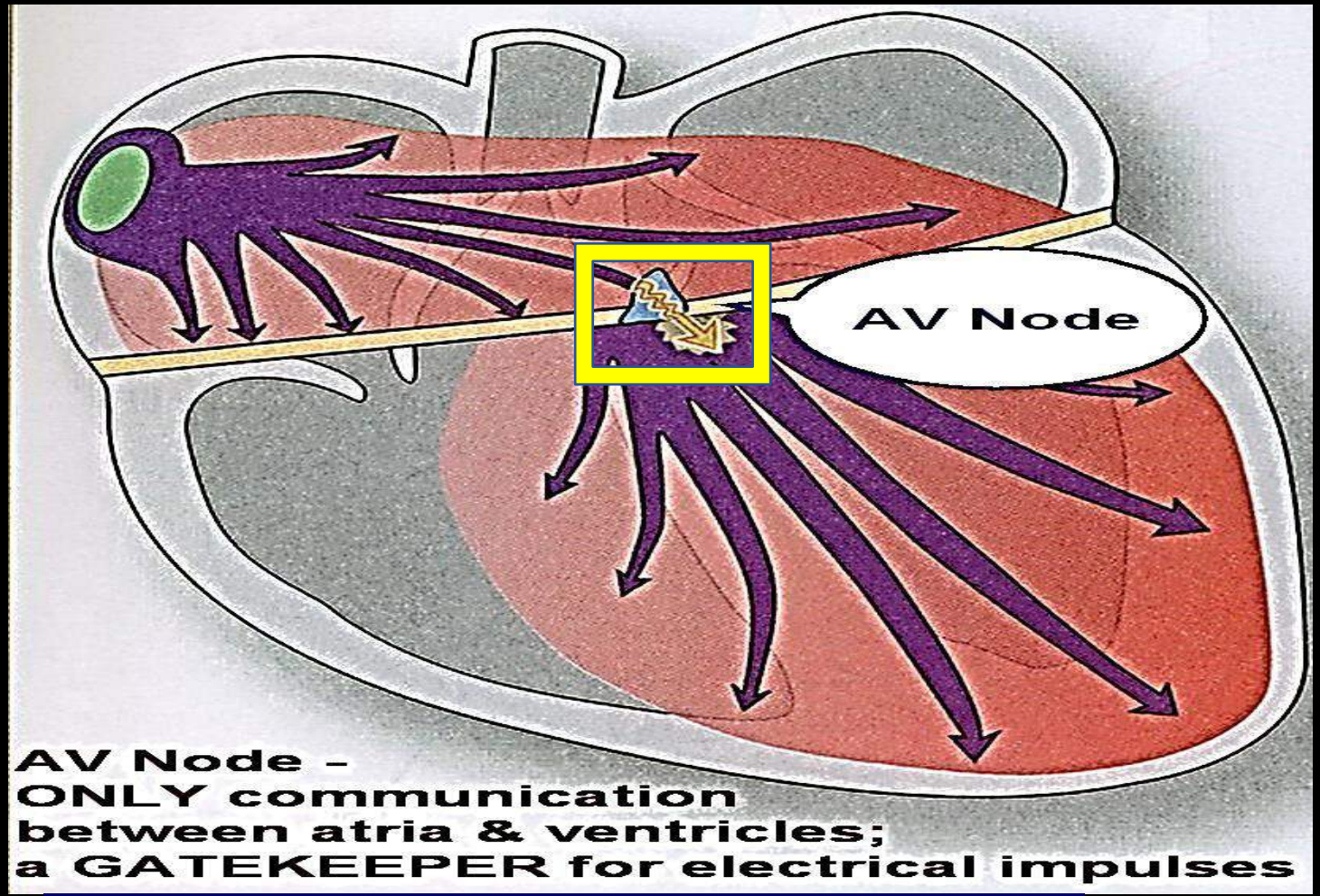


Wednesday, September 12, 2018

Dato Wira Dr L R Chandran Hospital Alor Star

"PLUS TOLL PLAZA"

controls

How many vehicles

"Go Through"

The AV Node

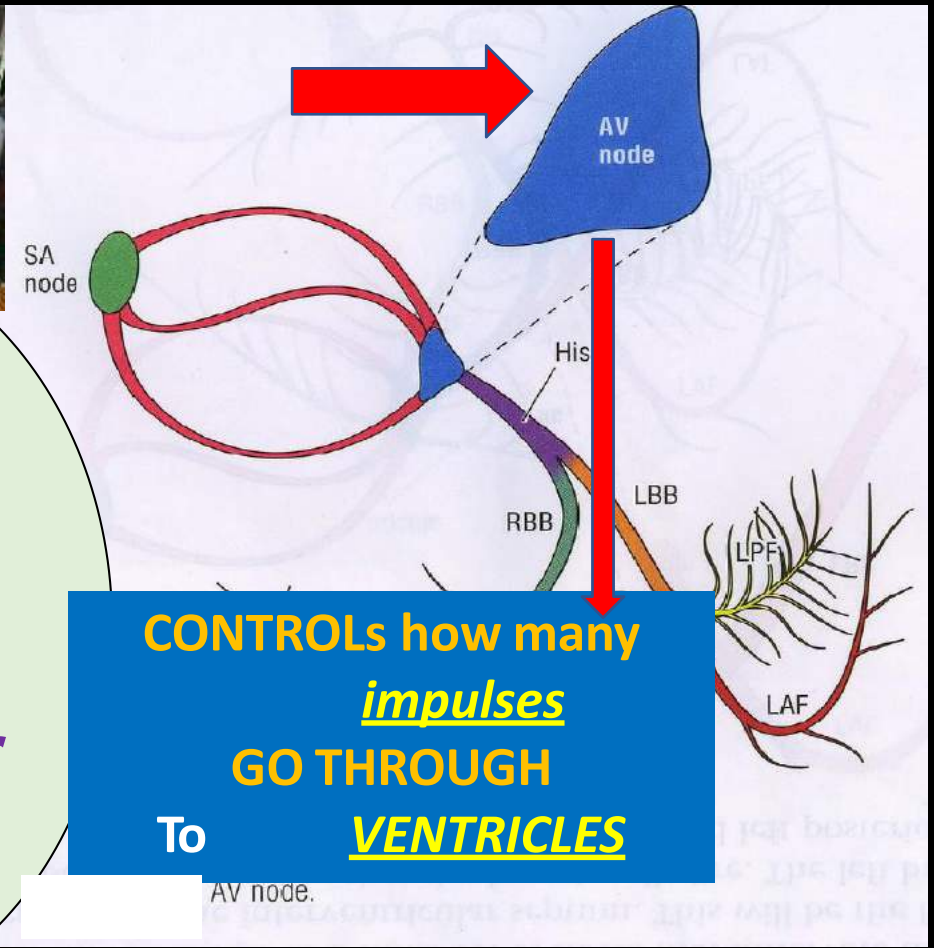
Is the

"PLUS TOLL"

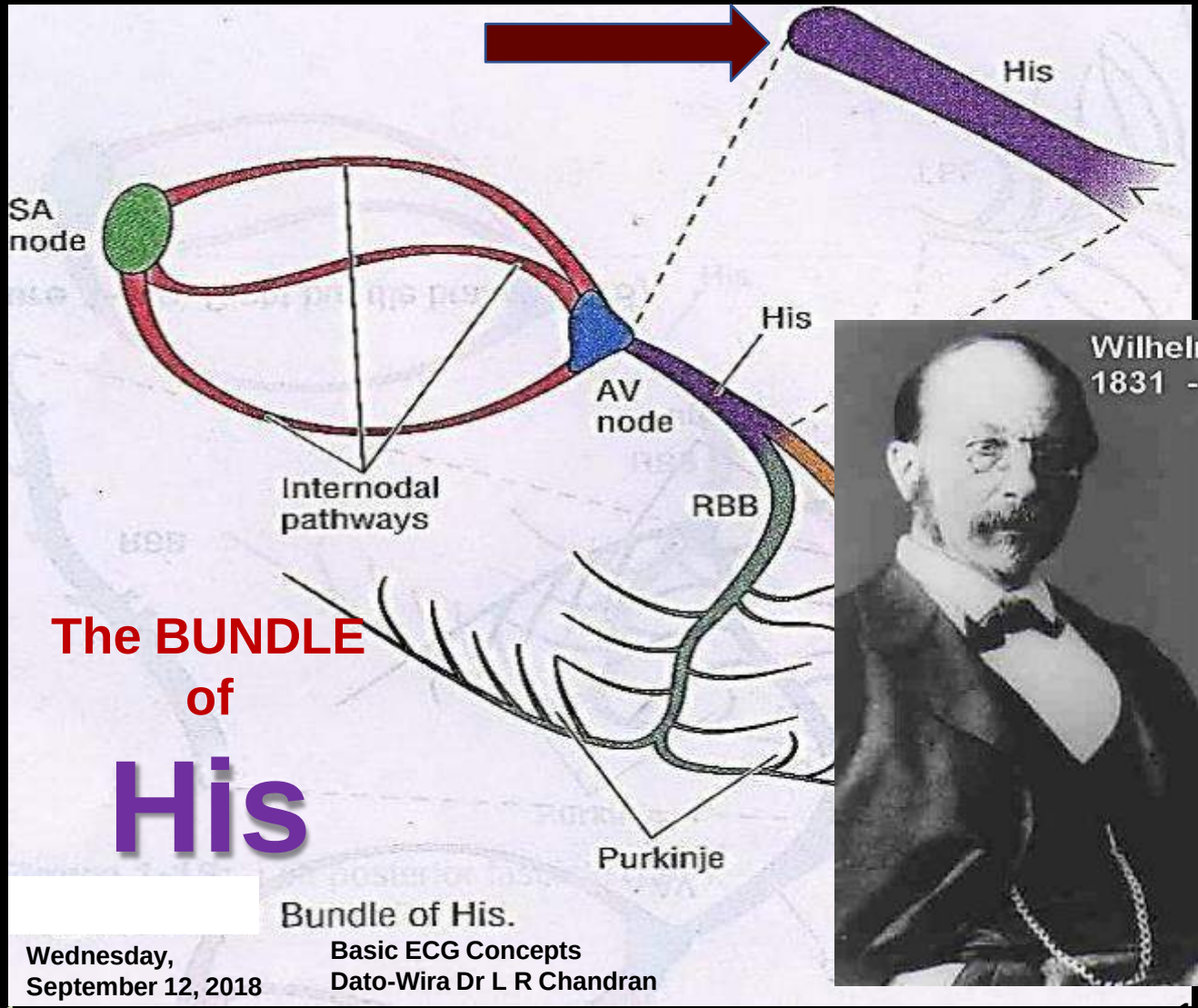
Speed controller

of the

HEART



CONTROLs how many ***impulses*** GO THROUGH To ***VENTRICLES***



The BUNDLE of His

Wednesday, September 12, 2018

Basic ECG Concepts
Dato-Wira Dr L R Chandran

Electrical

Impulses

arise from

ABOVE

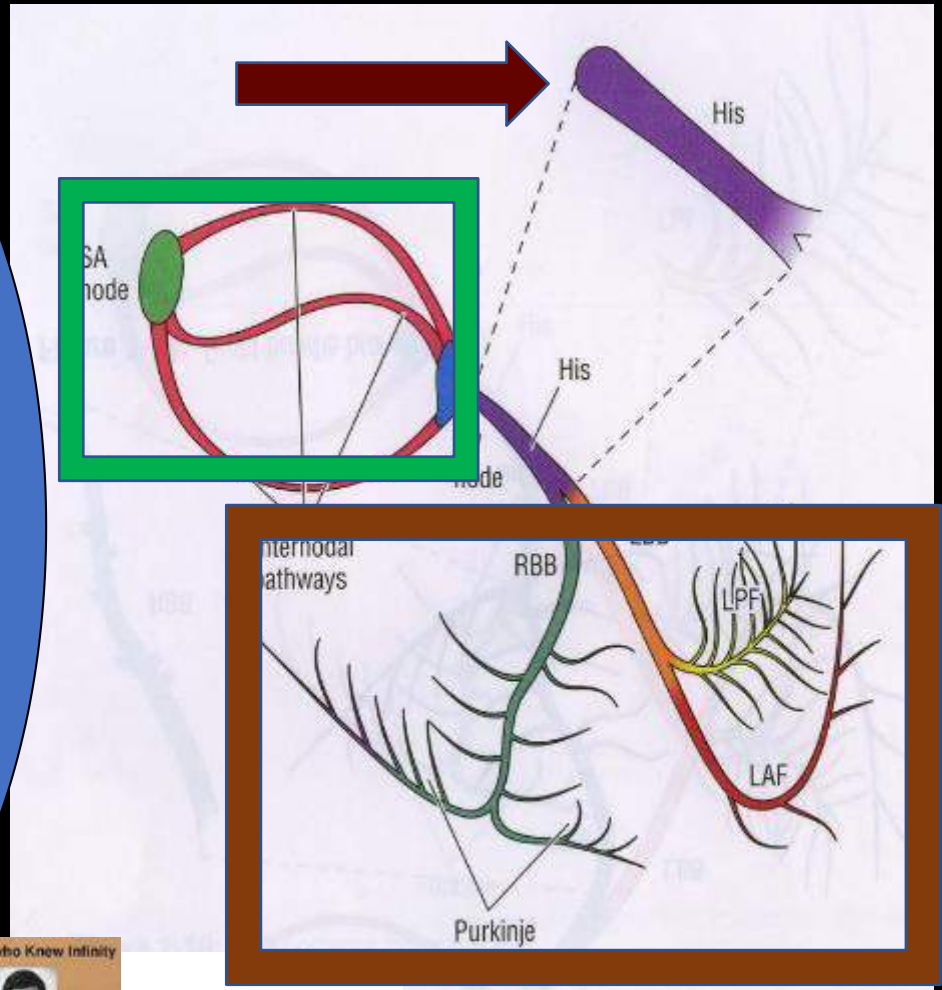
Or

BELOW

The

B of HIS

(cardiac Impulses = 'Heart Beat')



Basic ECG Concepts
Dato-Wira Dr L R Chandran

ABOVE

NARROW

QRS

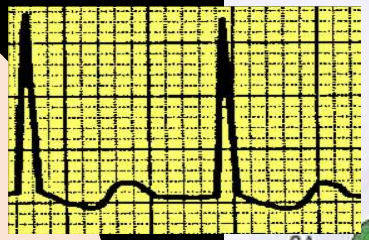
If *WIDE*

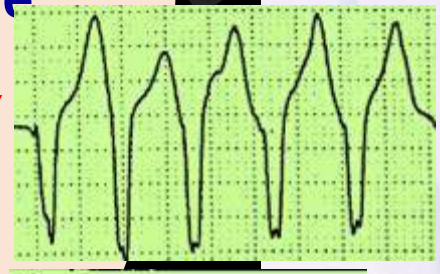
can be

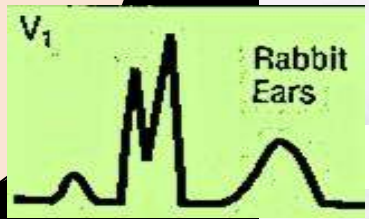
BELOW

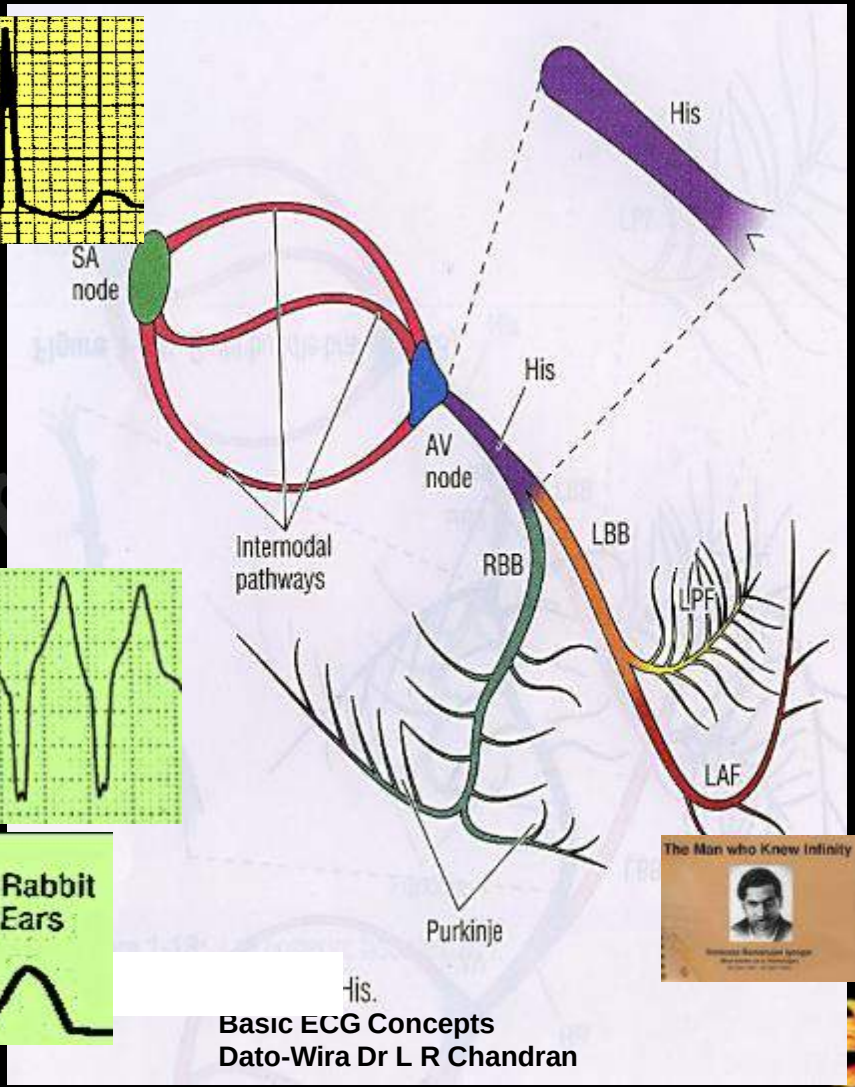
or

ABOVE



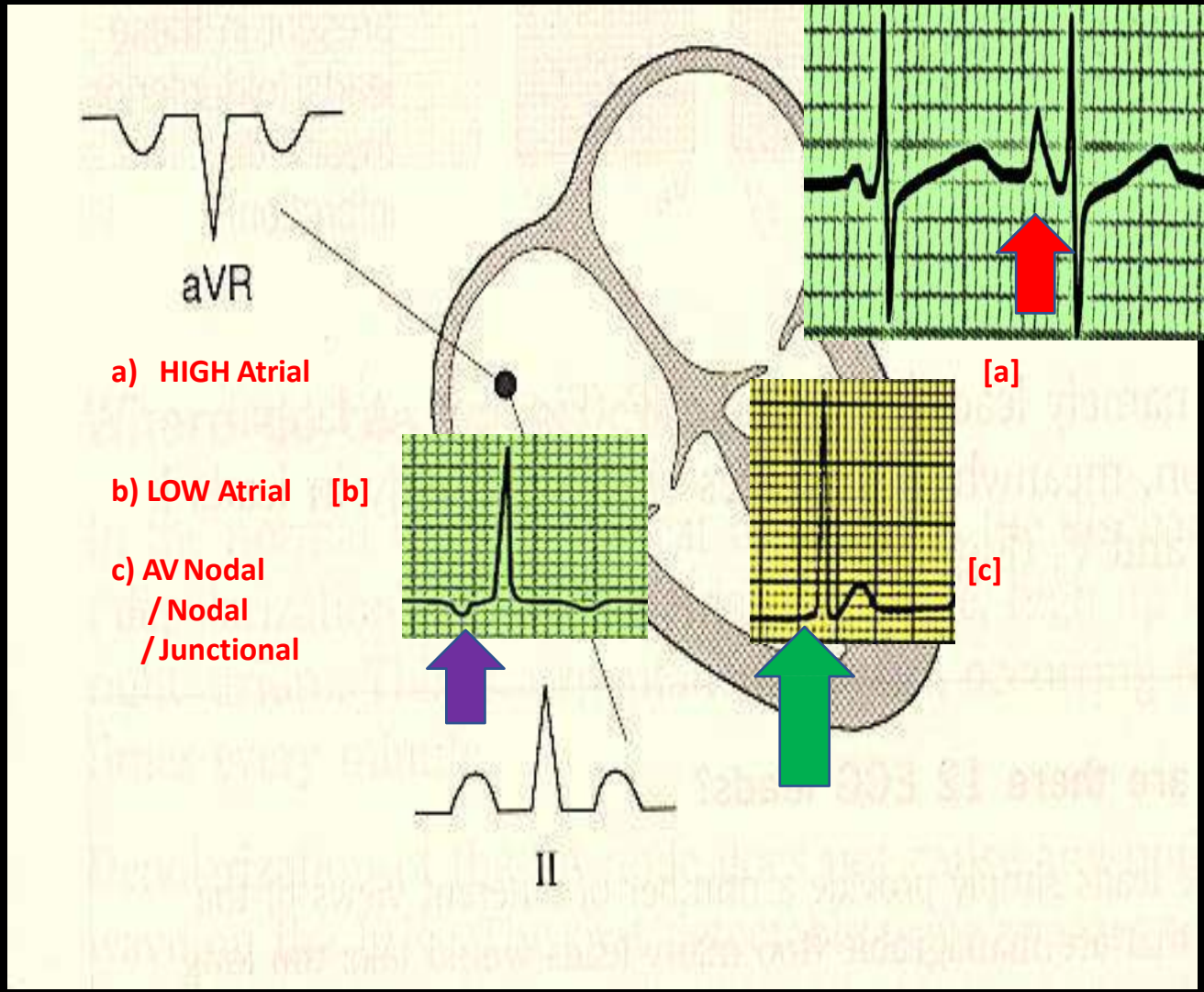




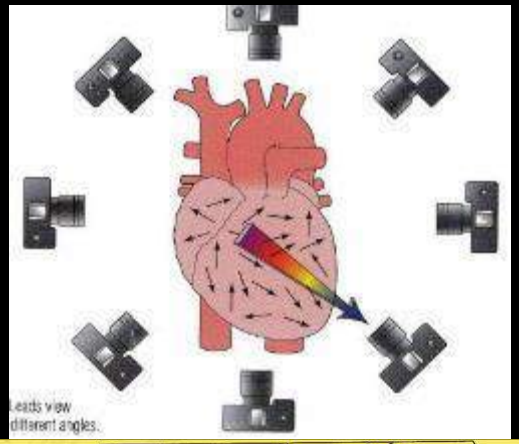


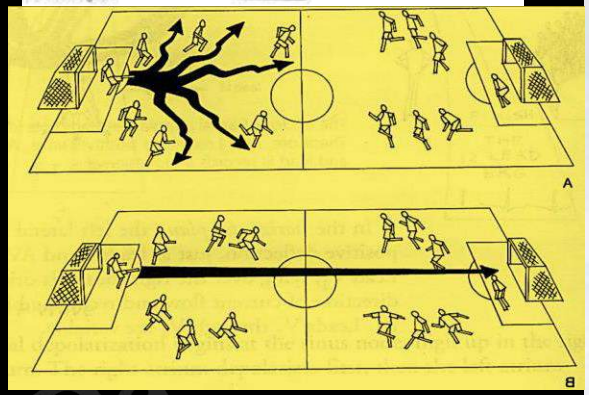
His.

Basic ECG Concepts
Dato-Wira Dr L R Chandran


aVR
a) HIGH Atrial
[a]
b) LOW Atrial
[b]
c) AV Nodal
/ Nodal
/ Junctional
[c]
II

Electrical Axis





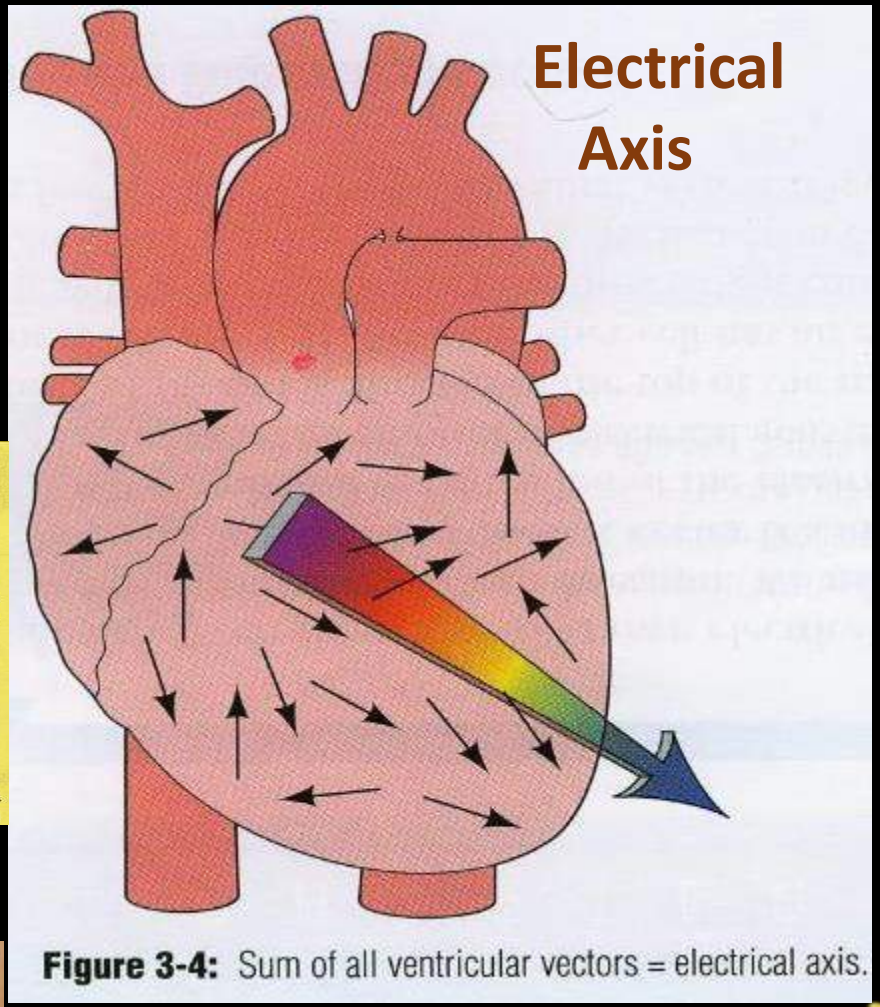
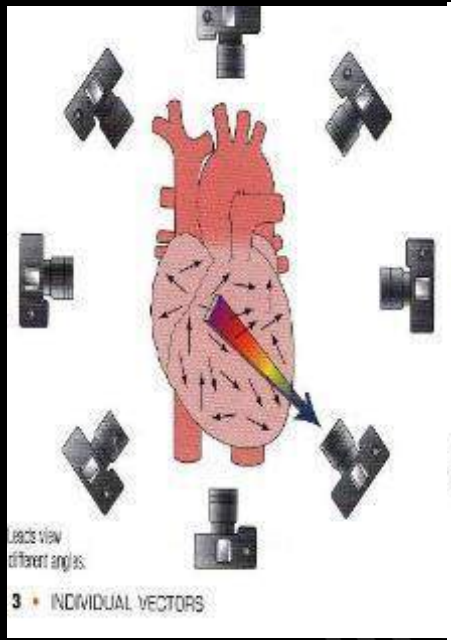


Figure 3-4: Sum of all ventricular vectors = electrical axis.



SIMILARLY

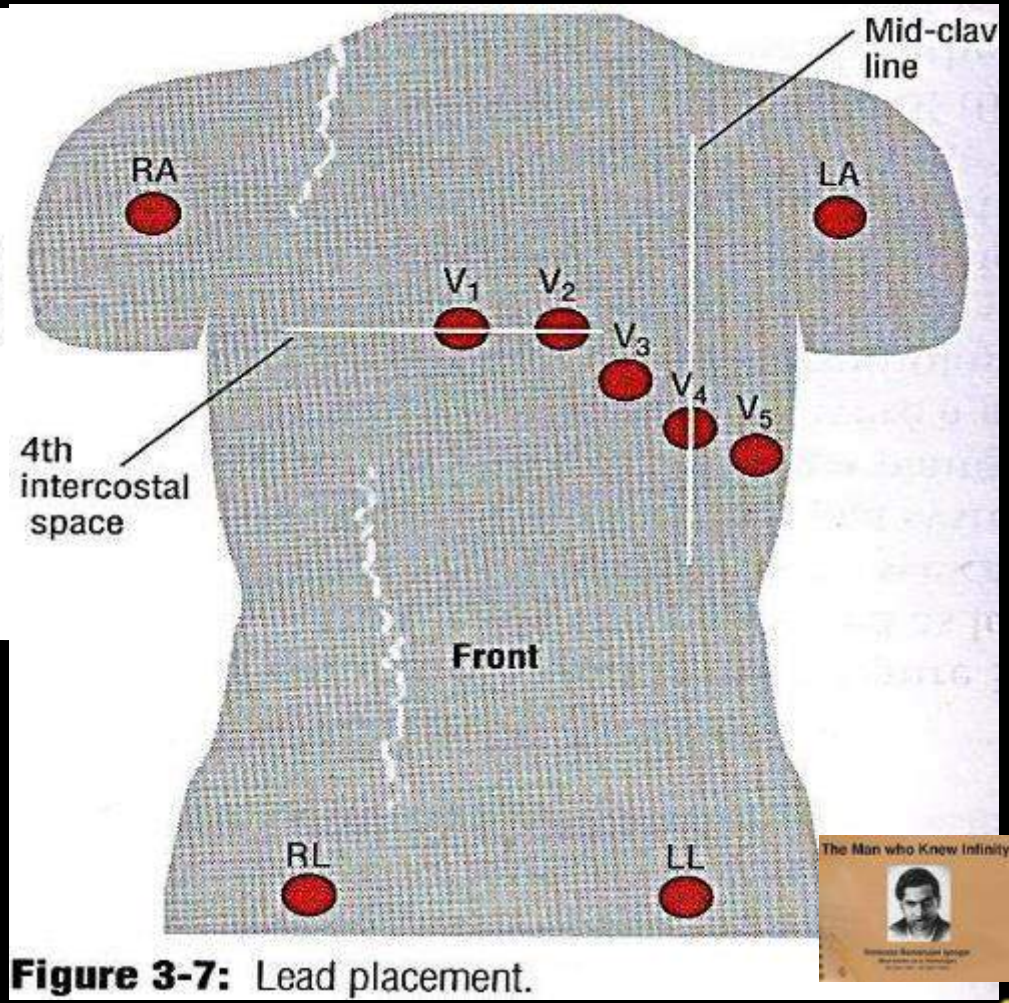


Figure 3-7: Lead placement.

The CONCEPT of an ECG Impulse [Beat]

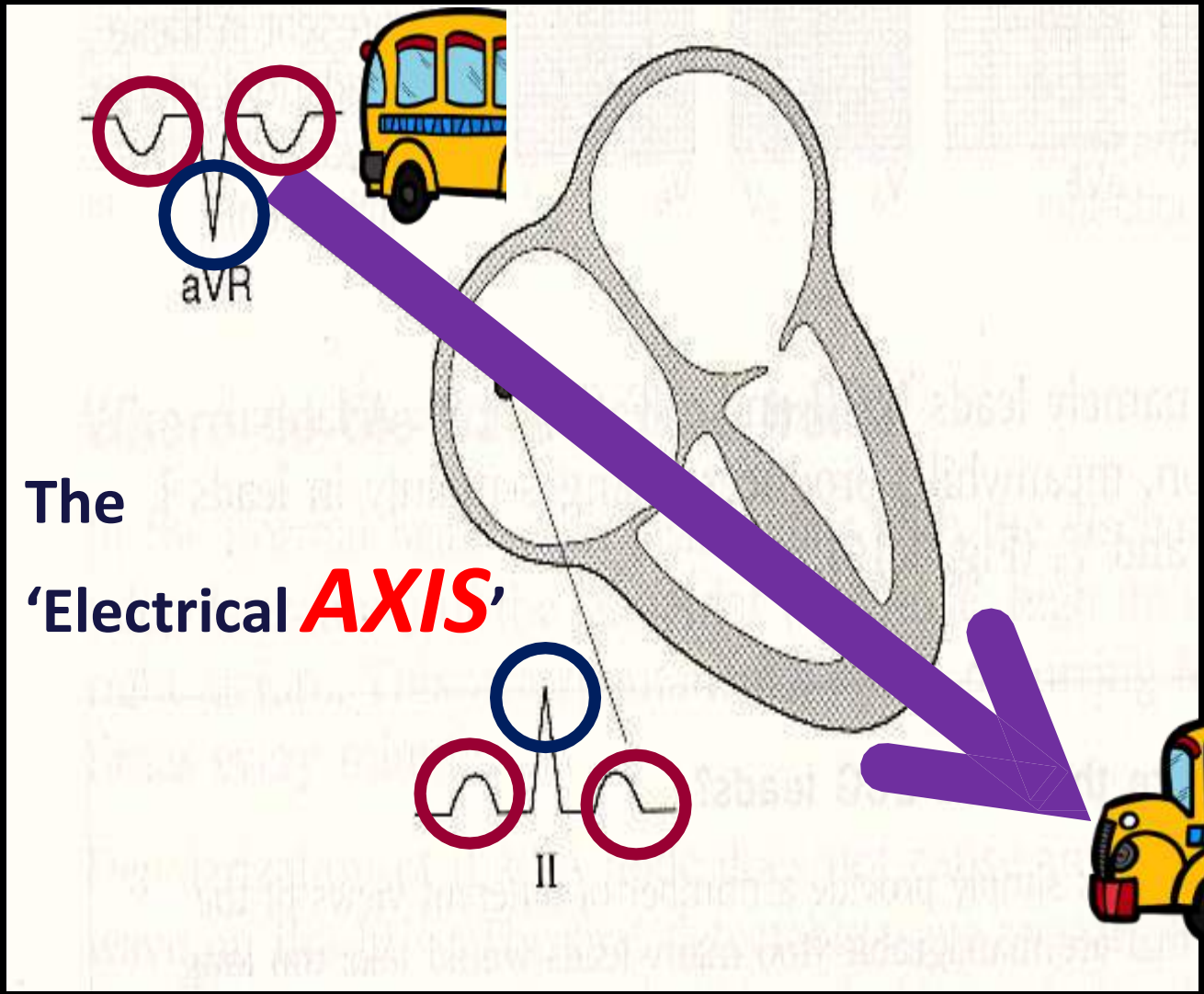
For EVERY Beat,

ASK

1) WHERE is the current ***STARTING*** from ?

2) In WHICH ***direction*** is it Travelling ?

3) WHERE does it ***TERMINATE*** [*END*] ?

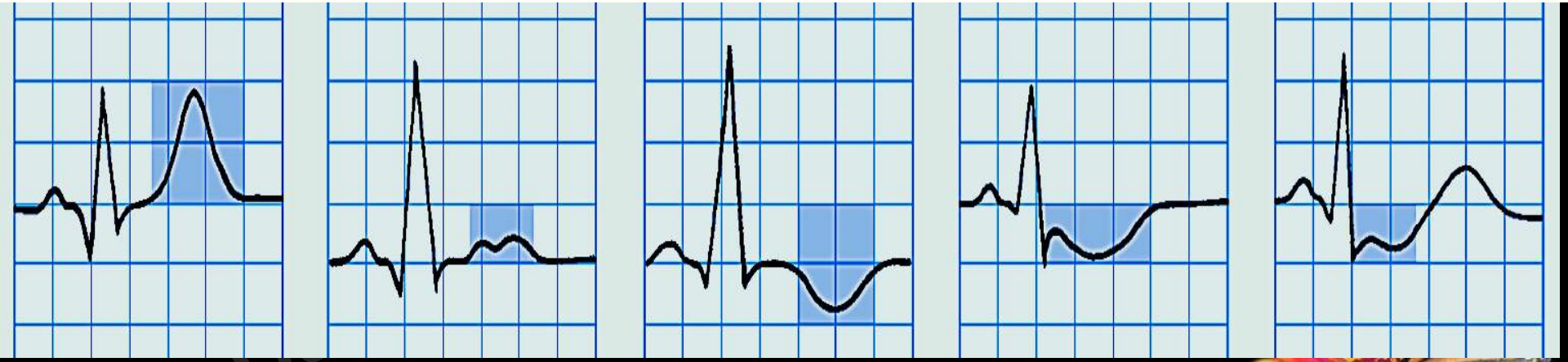


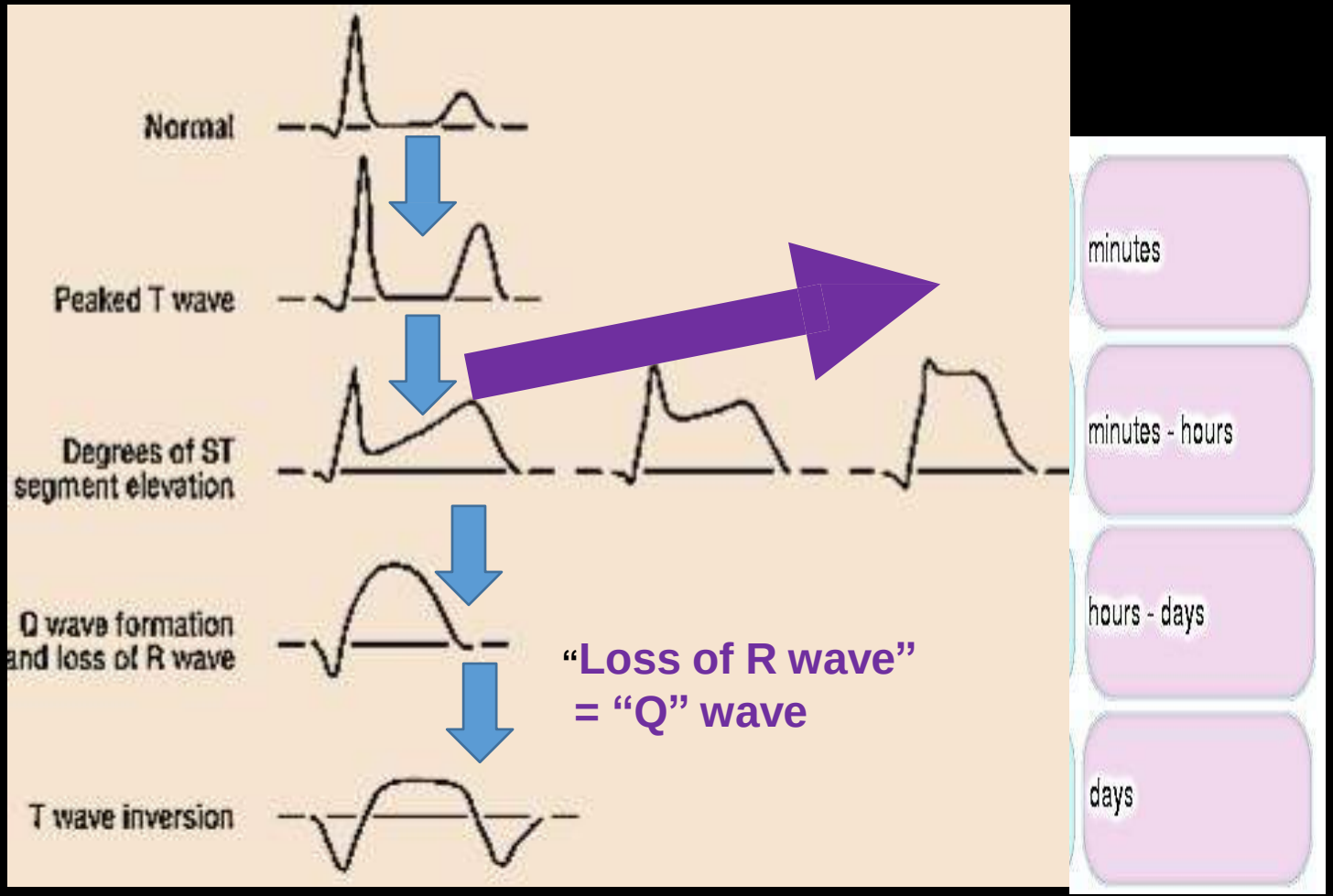
The 'Electrical *AXIS*'

ECG changes associated with angina

Here are some classic ECG changes involving the T wave and ST segment that you may see when monitoring a patient with angina.

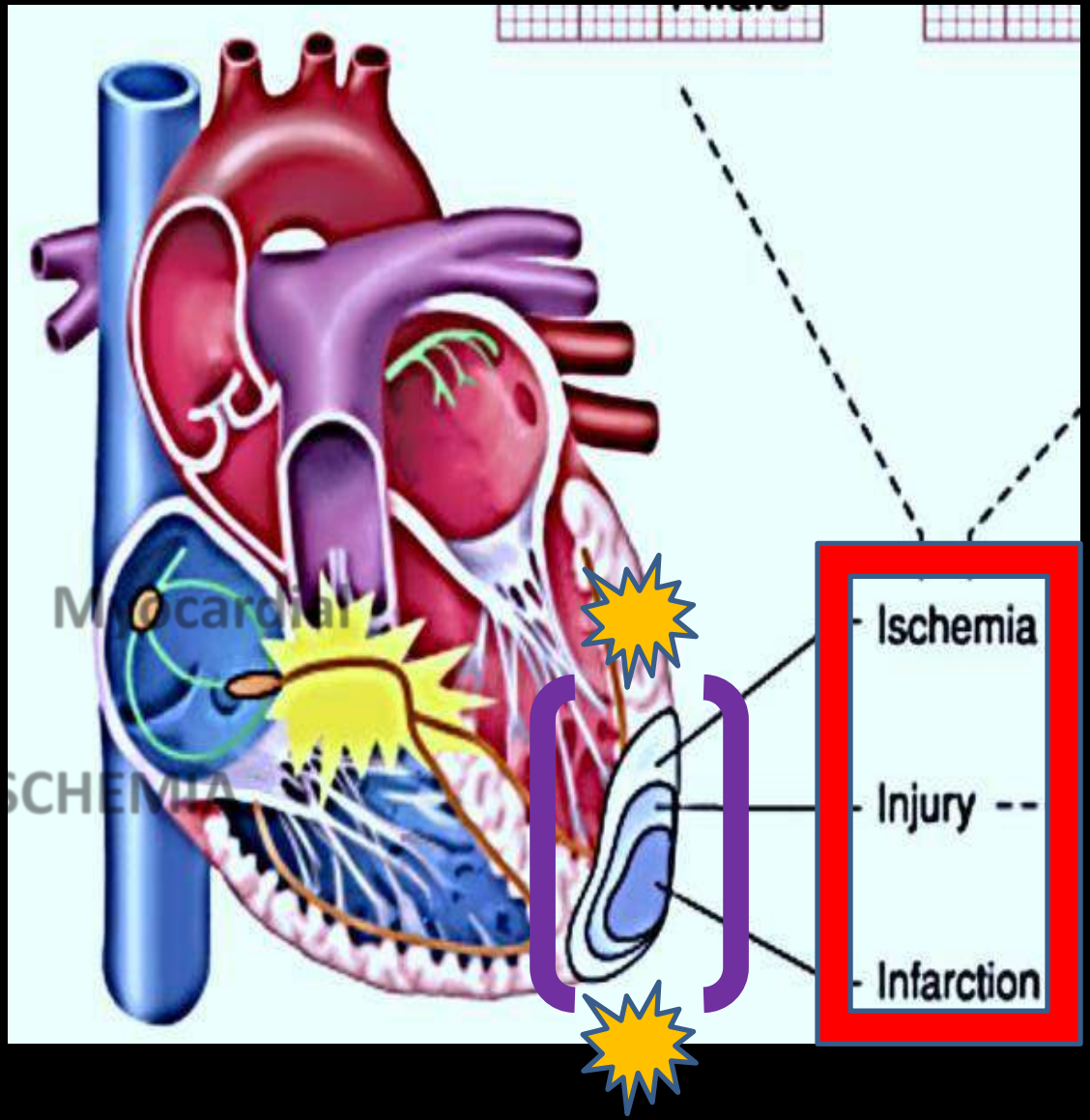
Peaked T wave | **Flattened T wave** | **T-wave inversion** | **ST-segment depression with T-wave inversion** | **ST-segment depression without T-wave inversion**



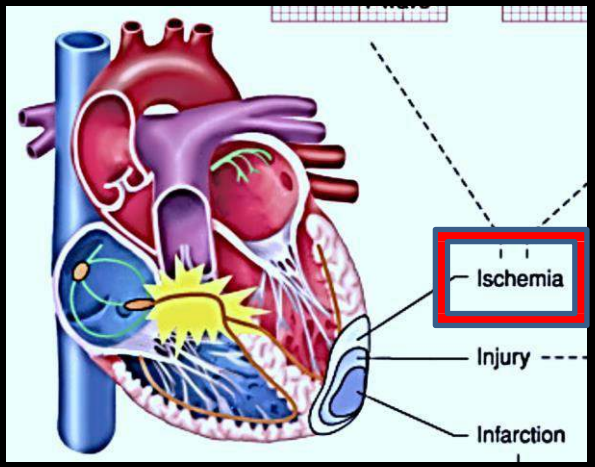


Sequence of changes seen during evolution of myocardial infarction

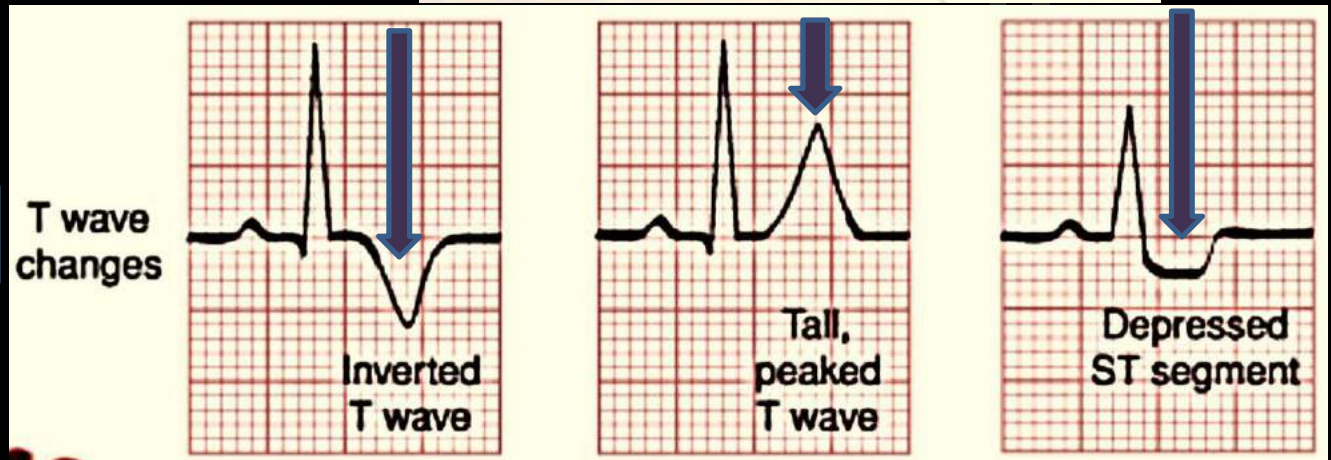
Sequence of changes in evolving AMI



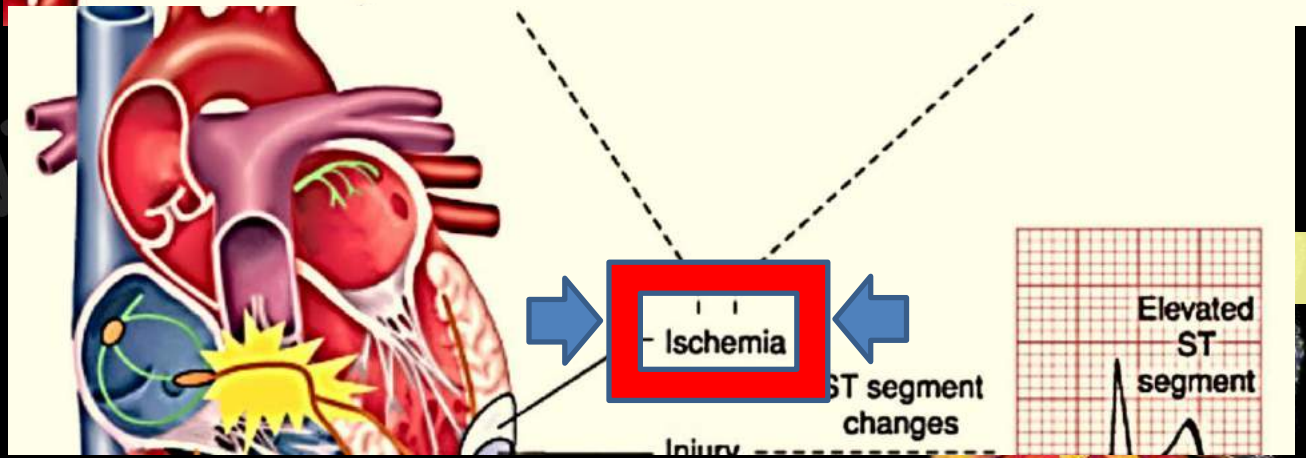
Myocardial Damage

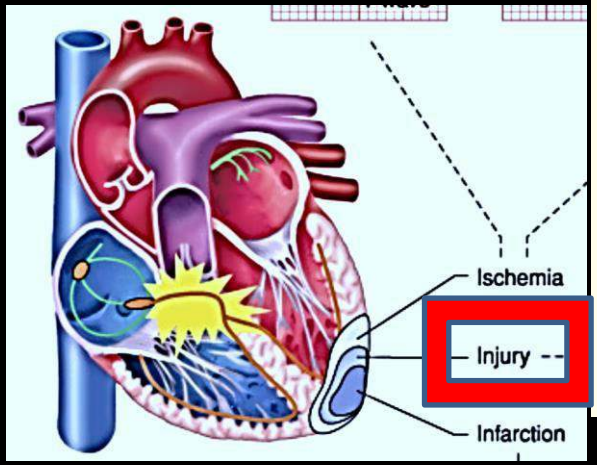


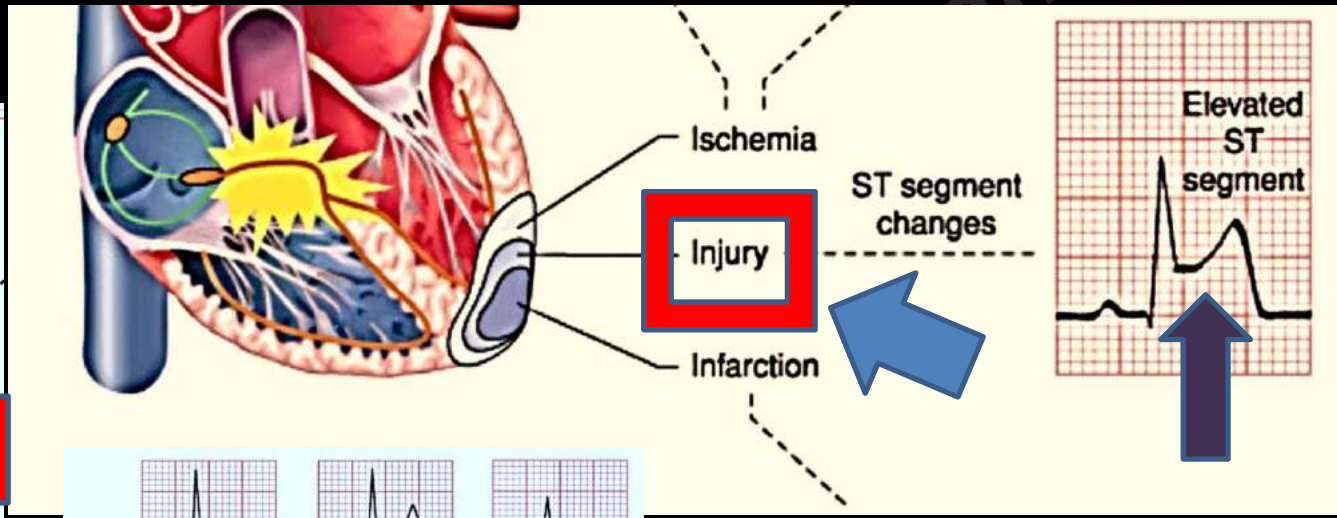
ECG Indicators

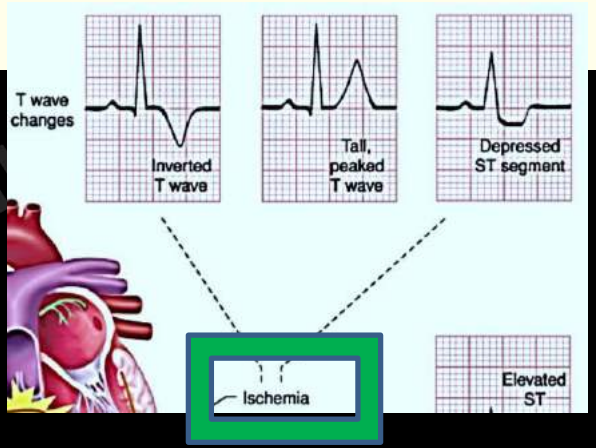


Myocardial
ISCHEMIA -2

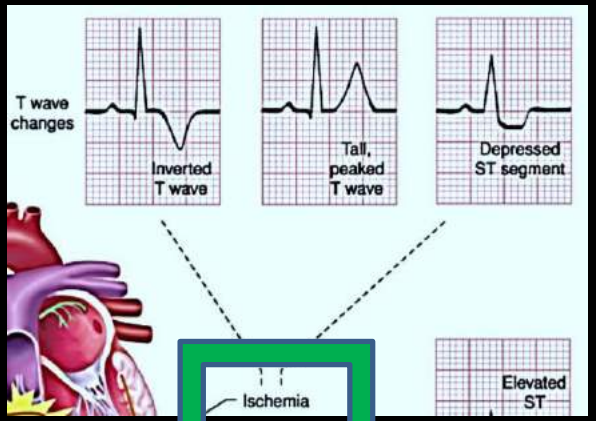


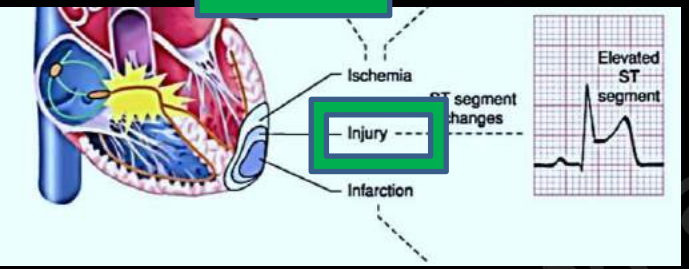


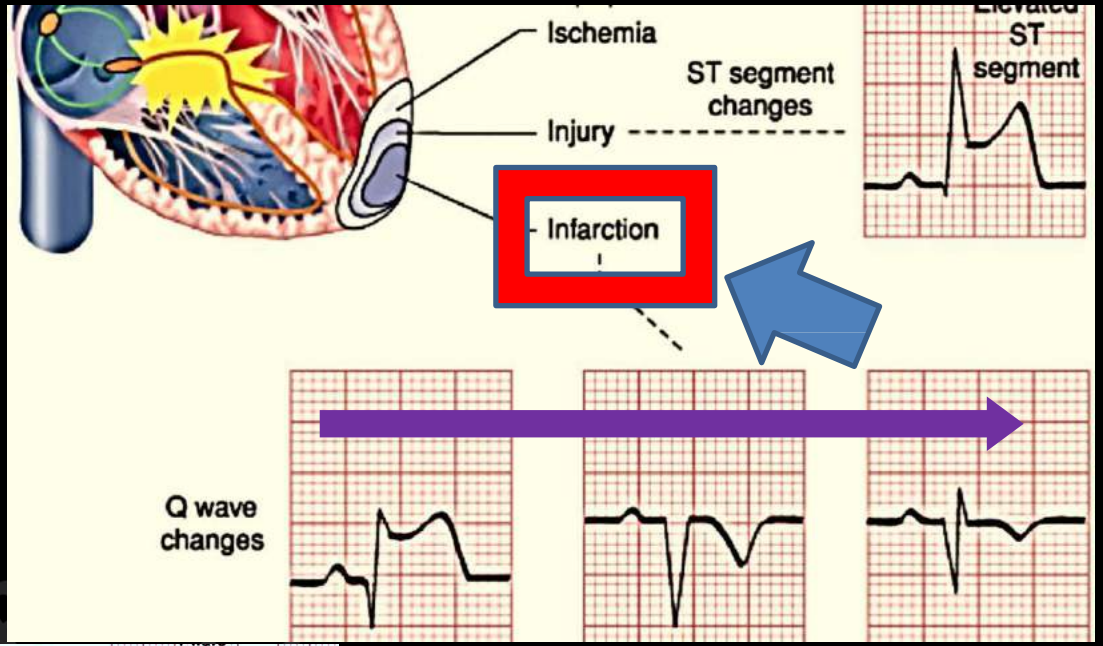


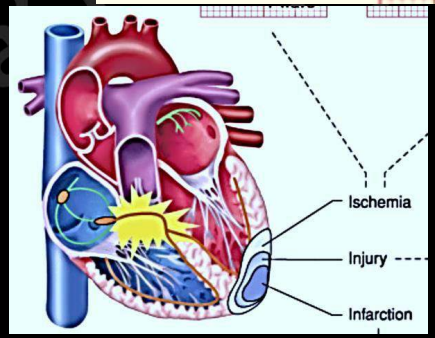


Myocardial INJURY -3









Myocardial Infarction -4

17 Normal Regular Rhythm with Narrow QRS

REGULAR NORMAL RHYTHM

A regular cardiac rhythm at a rate of 60 to 100 beats per minute is considered to be a normal rhythm.

REGULAR NORMAL RHYTHM

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If the QRS complexes during such a rhythm are narrow, it indicates normal intraventricular conduction and that the pacemaker is supraventricular in location. The pacemaker may be the S-A node, in the atrial myocardium or at the A-V junction.

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Let us examine the specific arrhythmias that are associated with these features.

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Let us examine the specific arrhythmias that are associated with these features.

NORMAL SINUS RHYTHM

The occurrence of sinus node discharge at a rate of 60 to 100 beats/min constitutes a normal sinus rhythm.

The rhythm is regular, the P wave and QRS complex are normal in morphology and they are related to each other with a 1:1 relationship.

NORMAL Sinus RHYTHM

Rhythm= **REGULAR**

Rate = **60 -100** beats / min

'P' to 'QRS' Relationship = **1:1**

NORMAL SINUS RHYTHM ---1 /3

- ✓ 1 If there is a **P** wave before every **QRS** complex,
- ✓ 2 An upright **P** wave in **Lead II** and
- ✓ 3 biphasic (up and down) **P** wave in lead **V1**. –see next slide

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NORMAL Sinus RHYTHM

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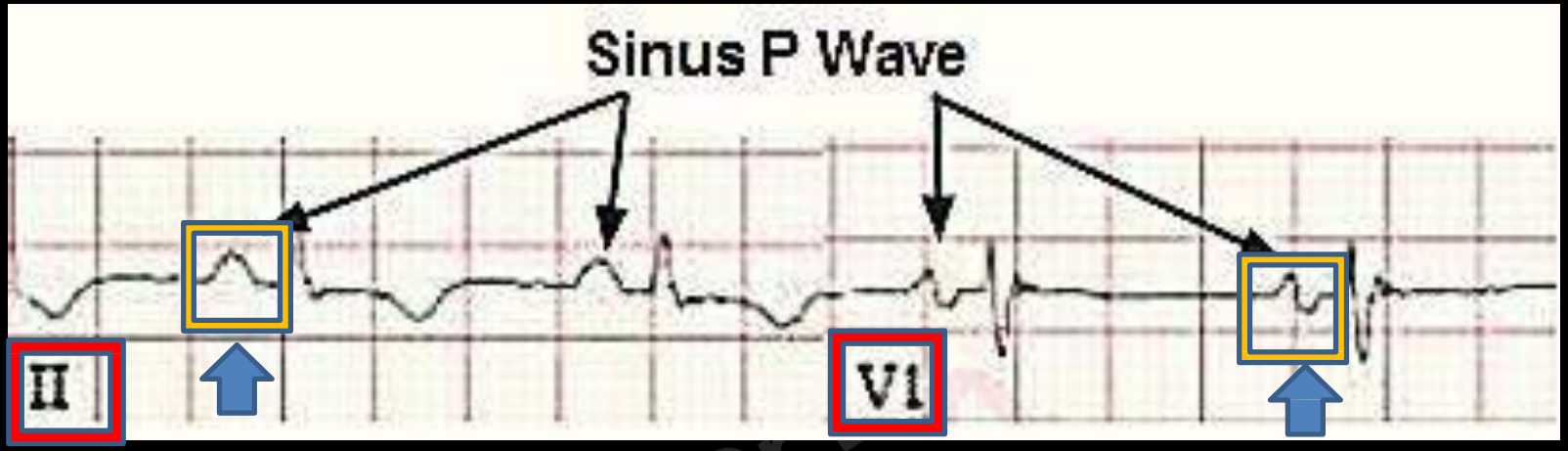
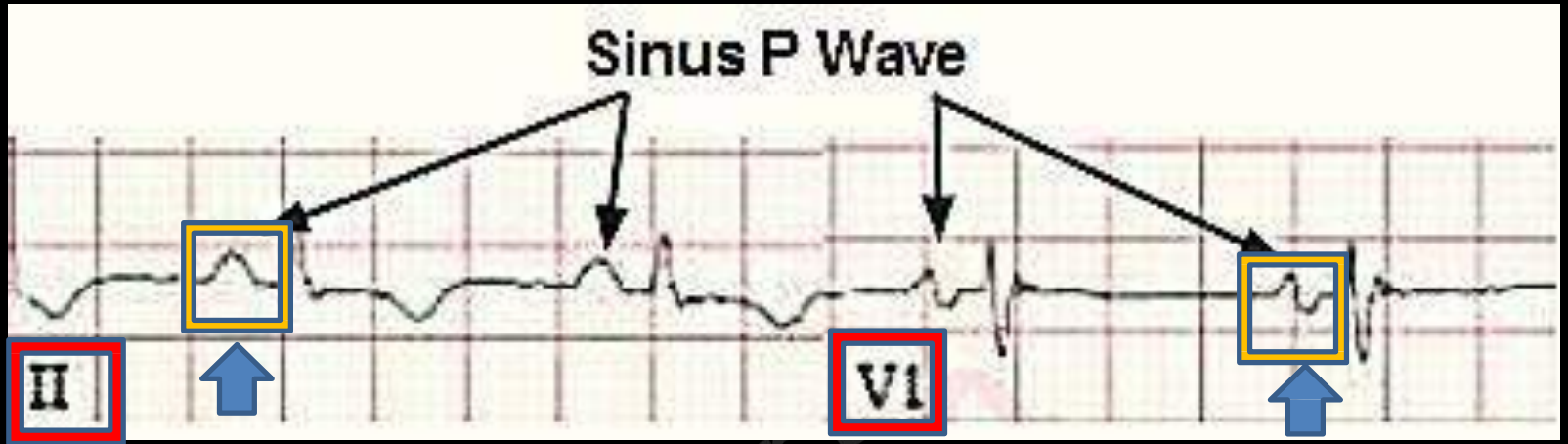


NORMAL SINUS RHYTHM ---2/ 3

1 If there is a **P** wave before every **QRS** complex,

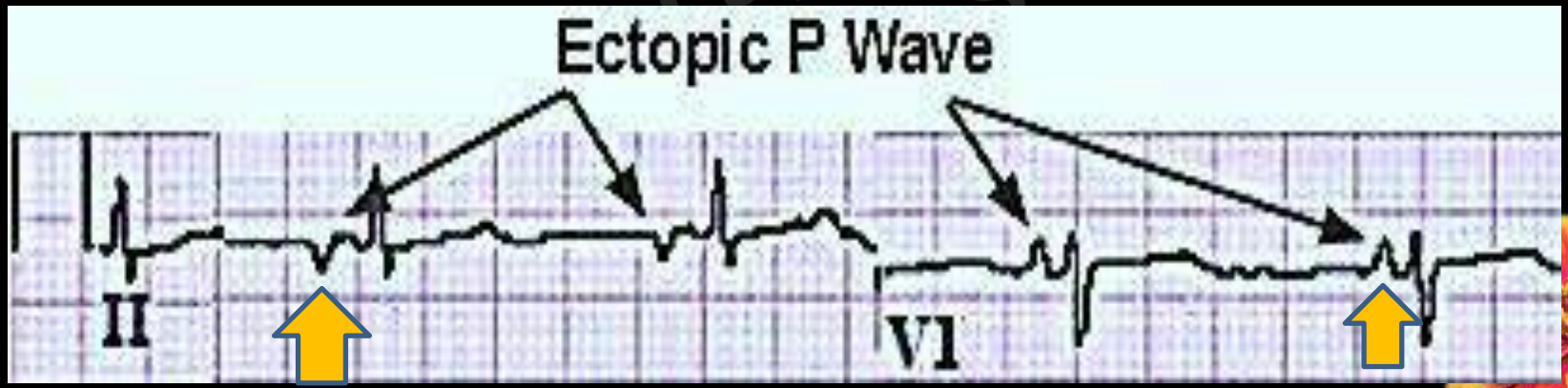
2 An upright **P** wave in lead **II** and biphasic (**up and down**) P wave in lead **V1.**



NORMAL SINUS RHYTHM **3 / 3**

1 If there is a P wave before every **QRS** complex,

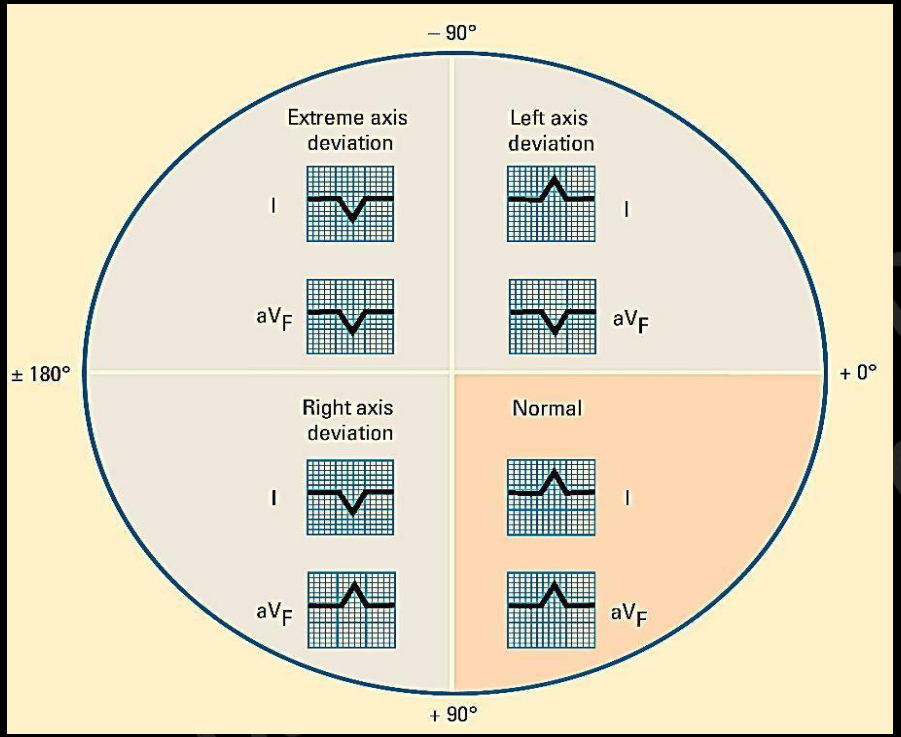
2 An upright **P** wave in lead **II** and biphasic (**up and down**) P wave in lead **V1.**

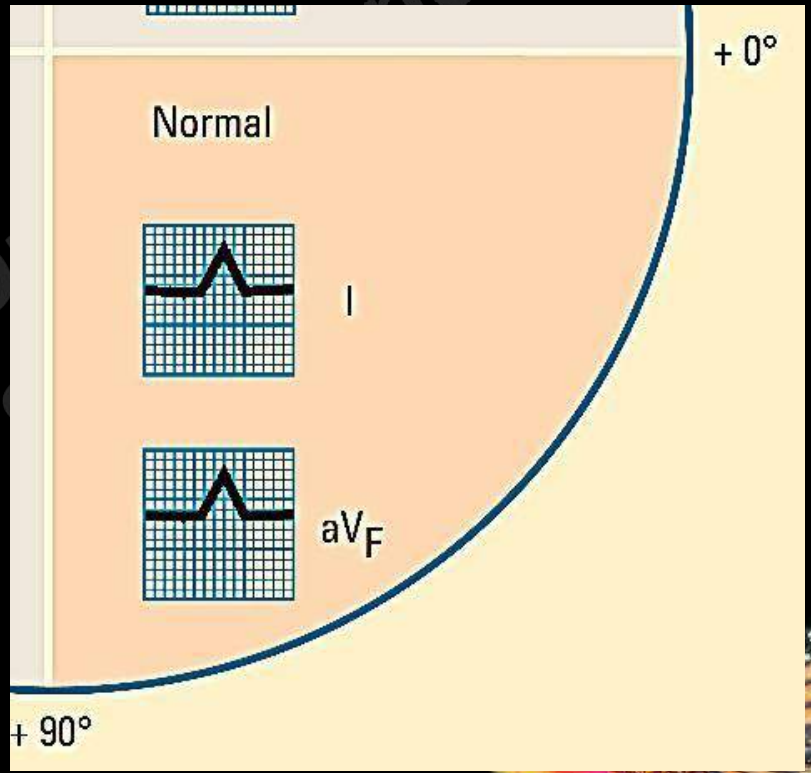


Electrical AXIS

Quadrant method

This chart will help you quickly determine the direction of a patient's electrical axis. Just observe the deflections of the QRS complexes in leads I and aV_F. Then check the chart to determine whether the patient's axis is normal or has a left, right, or extreme axis deviation.



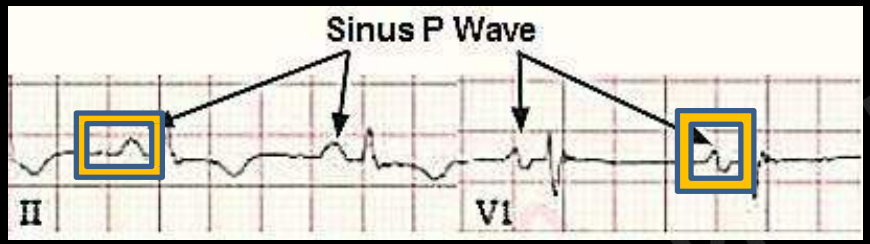


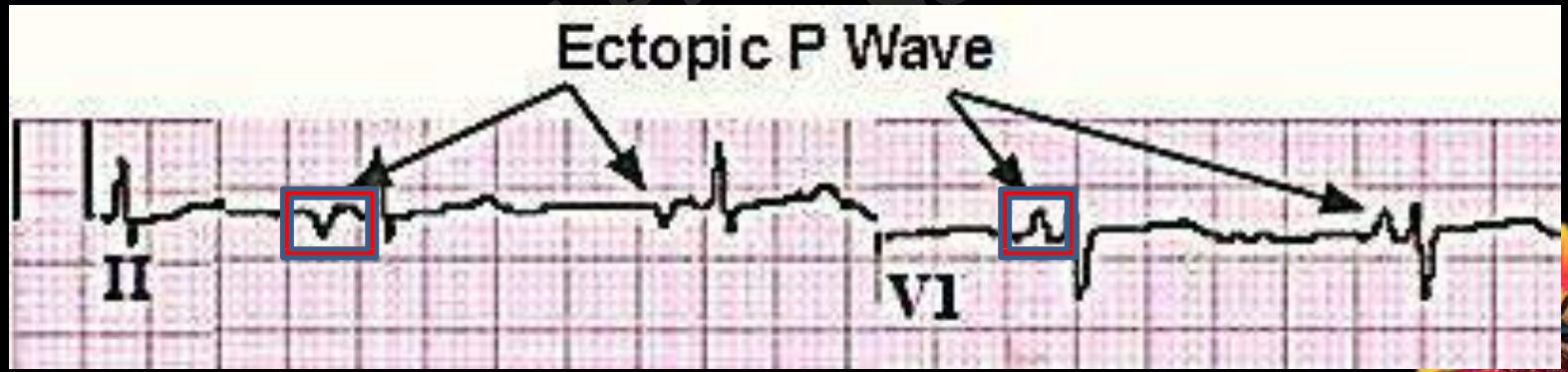
Ectopic atrial rhythms *[including*

- ✓ ***atrial tachycardia,***
- ✓ ***multifocal atrial tachycardia and***
- ✓ ***junctional rhythms***]

all have ***P waves*** → ***that are not of sinus-node ORIGIN***

ECTOPIC atrial rhythms occur→ **when a site outside of the sinus node, but within the atria,**
[*and* → *faster than the sinus node*.]

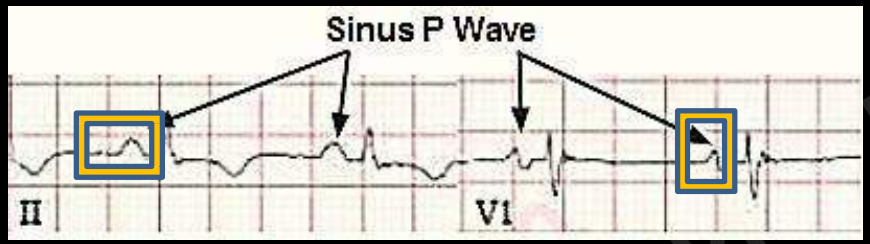


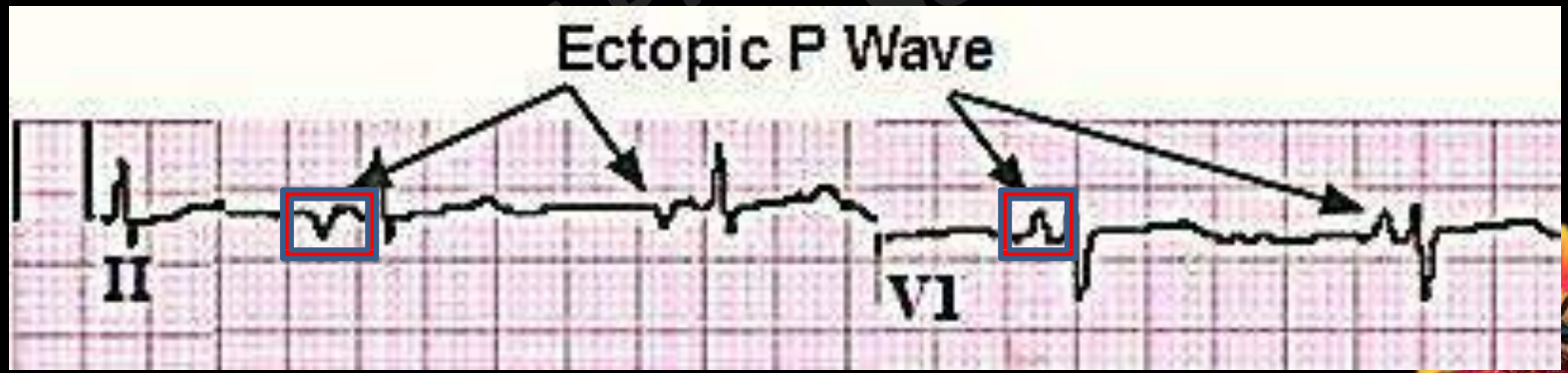


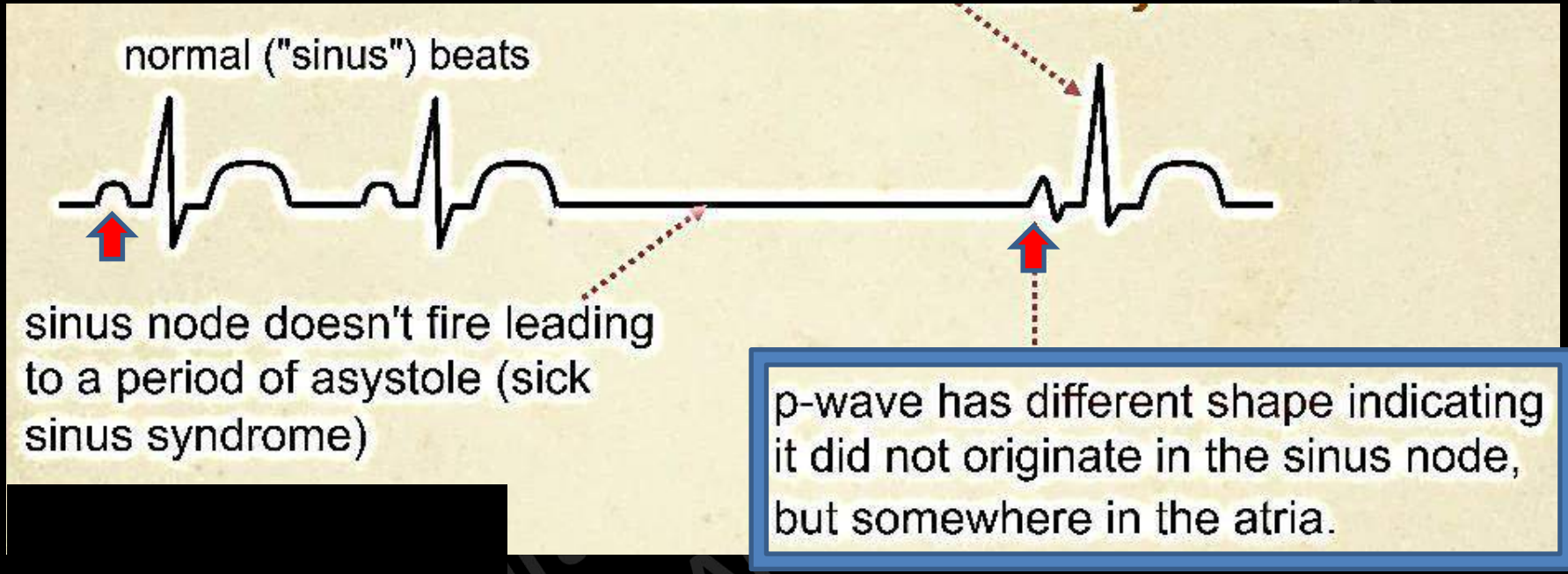
P wave **would not** have its normal sinus appearance
— that is, NOT upright in lead II and NOT biphasic in V1.

However, it would have a different **SHAPE** depending on exactly where it originates.

This is referred to as an "ectopic atrial rhythm" or "ectopic P wave."

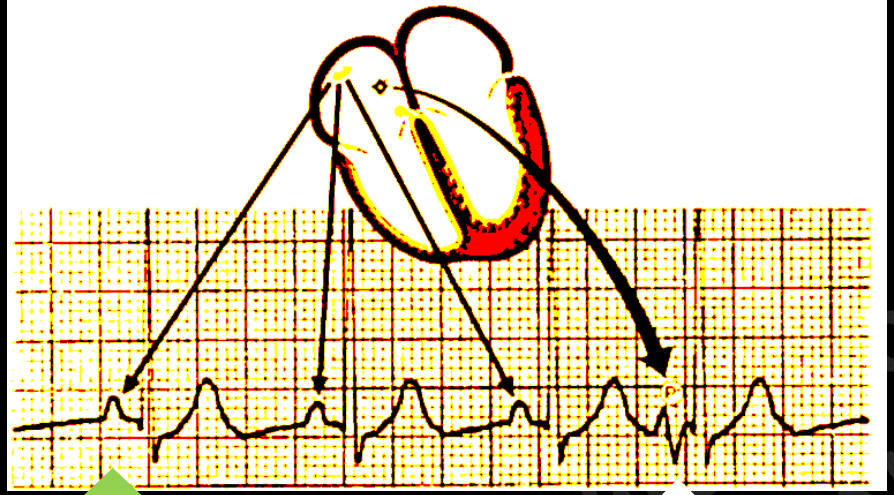




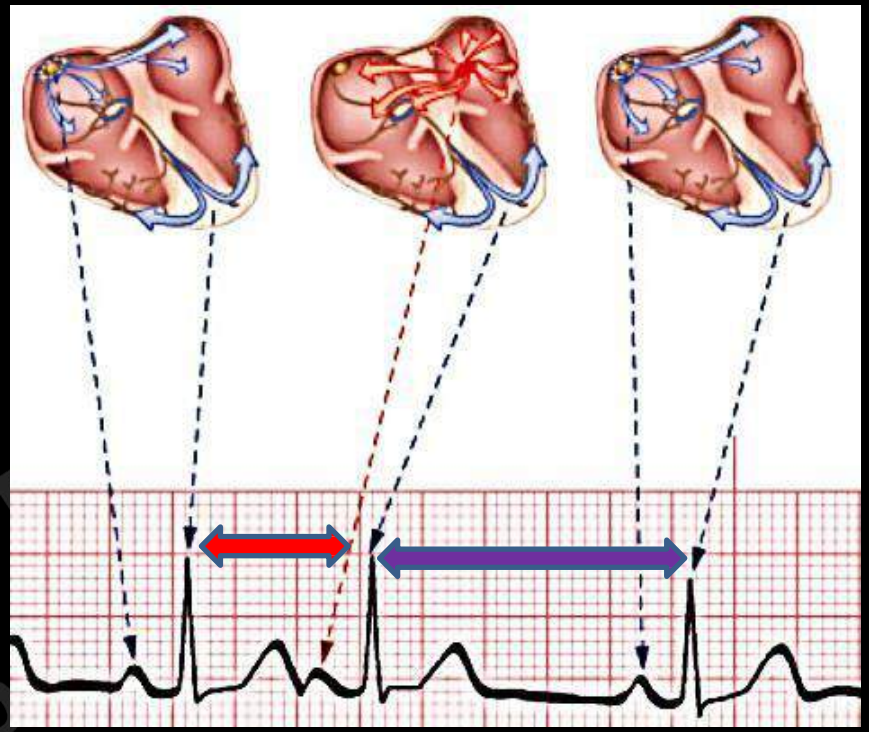

normal ("sinus") beats
sinus node doesn't fire leading to a period of asystole (sick sinus syndrome)
p-wave has different shape indicating it did not originate in the sinus node, but somewhere in the atria.

Atrial Escape Beats

Premature Atrial Beat

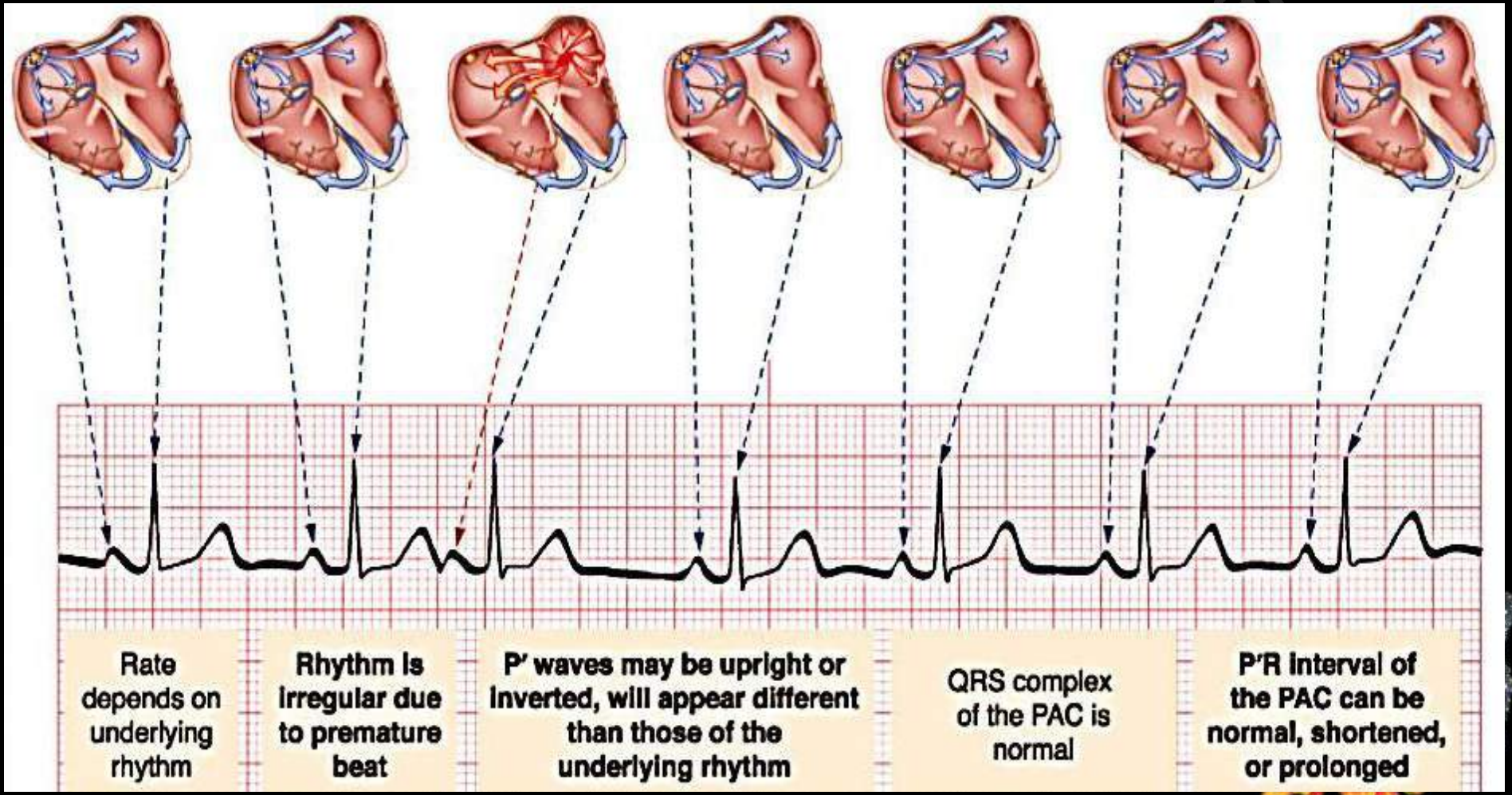


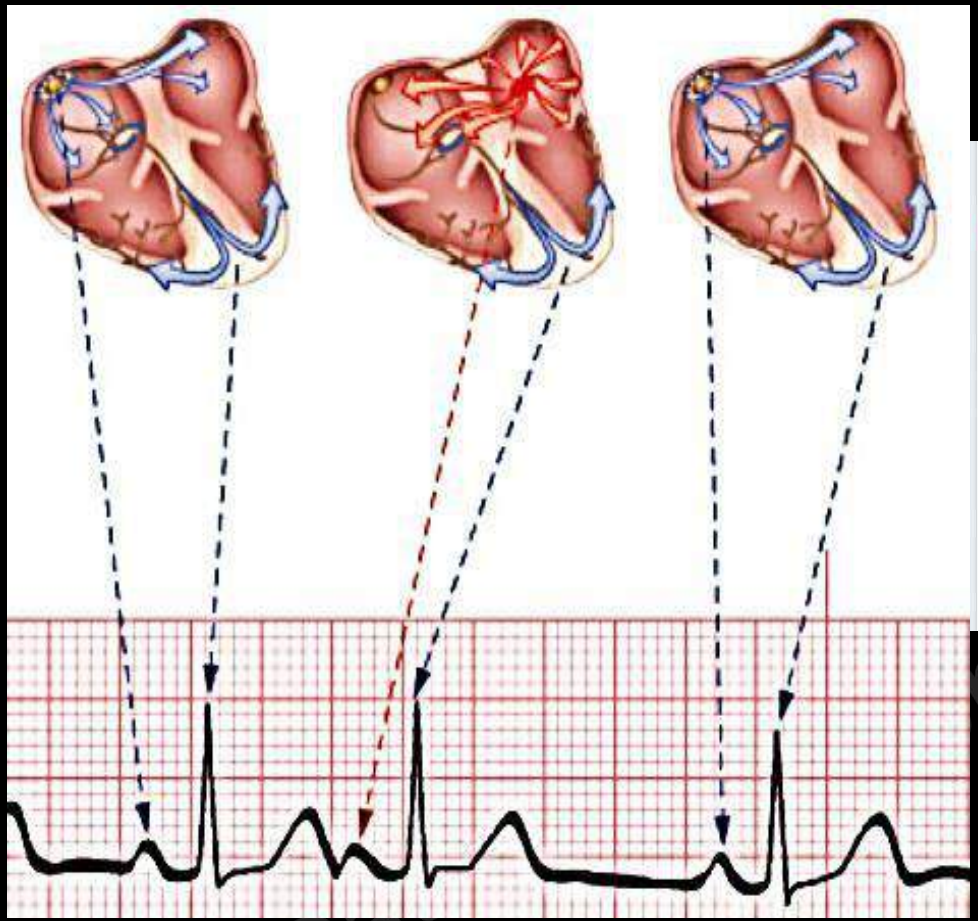
SINUS P NON Sinus P

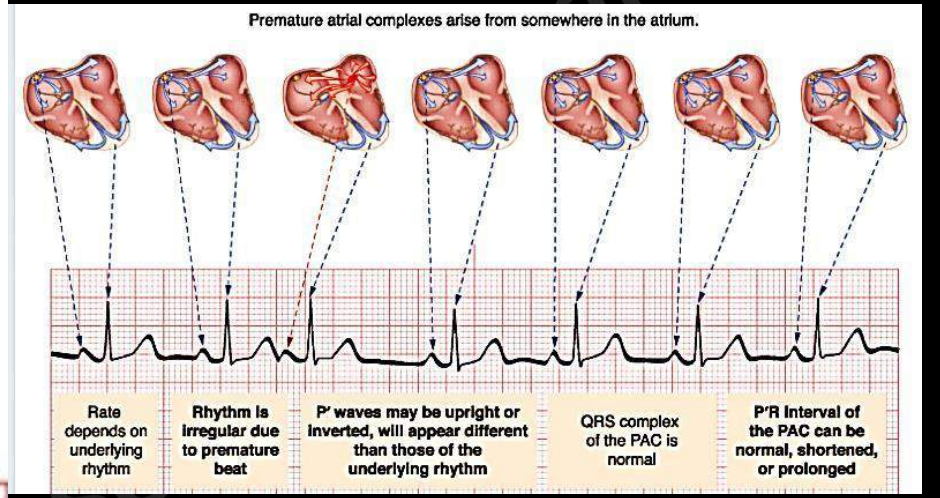


SINUS P NON Sinus P

Premature atrial complexes arise from somewhere in the atrium.



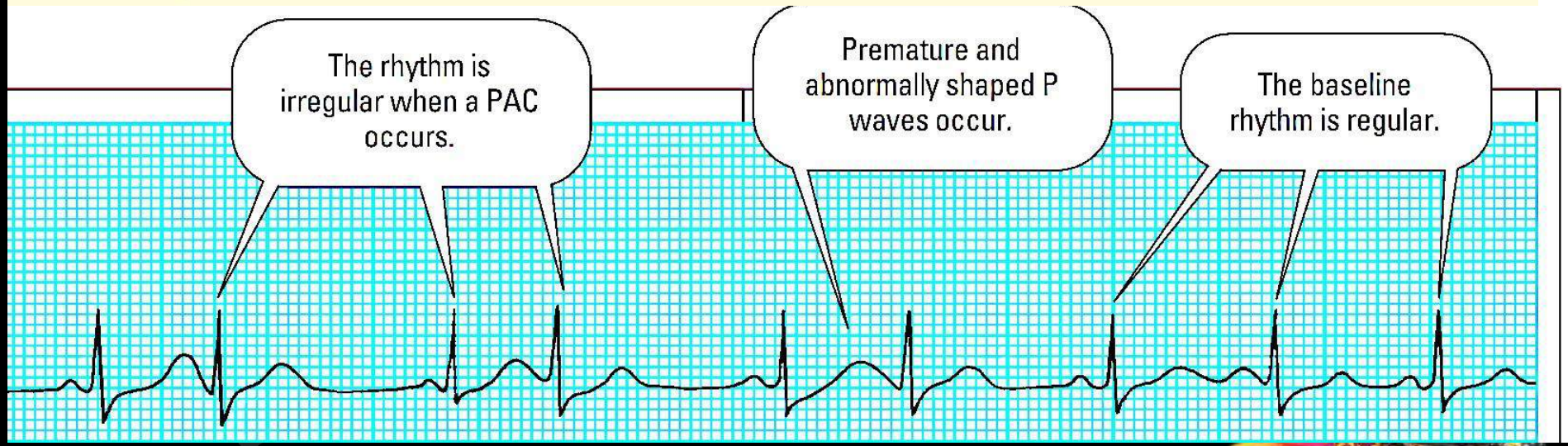



Premature atrial complexes arise from somewhere in the atrium.
Rate depends on underlying rhythm
Rhythm is irregular due to premature beat
P' waves may be upright or inverted, will appear different than those of the underlying rhythm
QRS complex of the PAC is normal
P'R interval of the PAC can be normal, shortened, or prolonged

Identifying premature atrial contractions

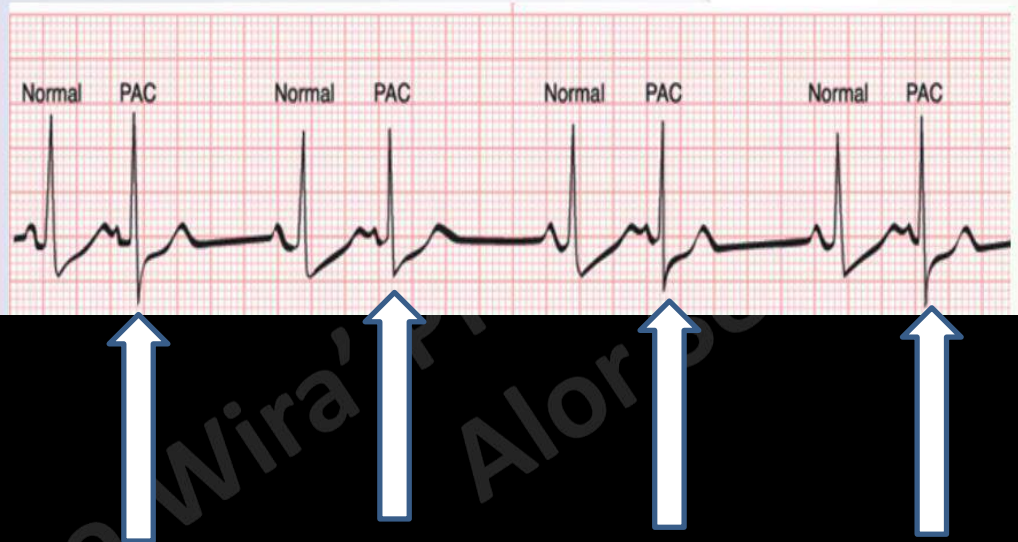
This rhythm strip illustrates premature atrial contraction (PAC). Look for these distinguishing characteristics.

- *Rhythm:* Irregular
- *Rate:* 90 beats/minute
- *P wave:* Abnormal with PAC; some lost in previous T wave
- *PR interval:* 0.20 second
- *QRS complex:* 0.08 second
- *T wave:* Abnormal with some embedded P waves
- *QT interval:* 0.32 second
- *Other:* Noncompensatory pause (first PAC)



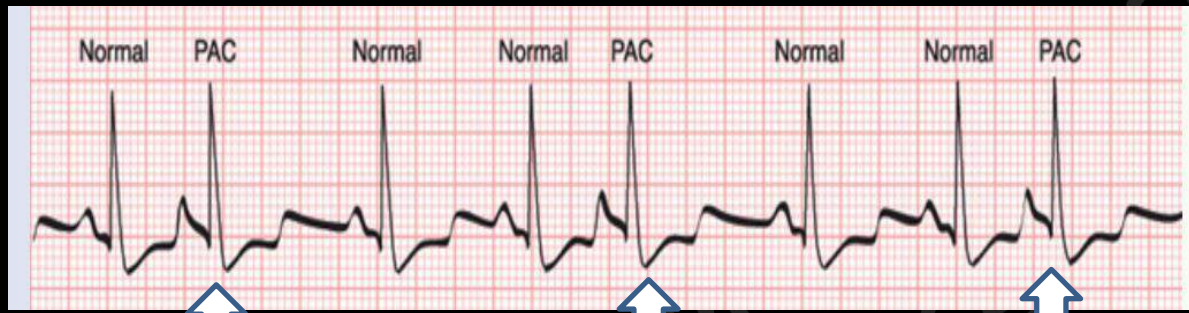
S 60 B 80 C 40

Premature Atrial Complexes

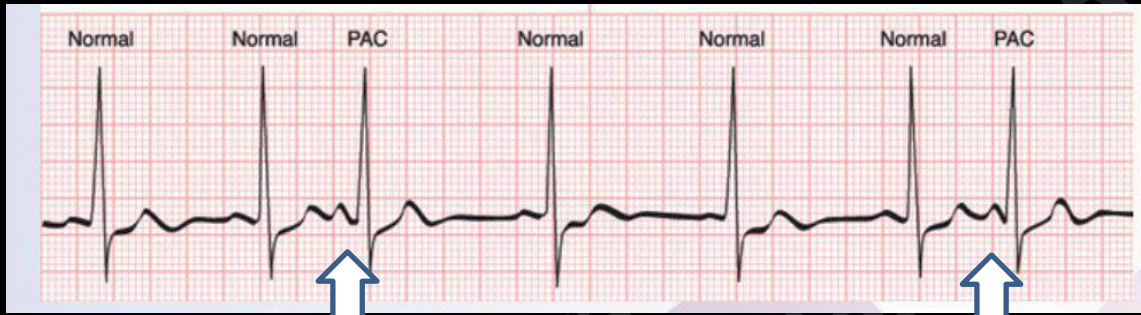


Bigeminal

Premature Atrial Complexes



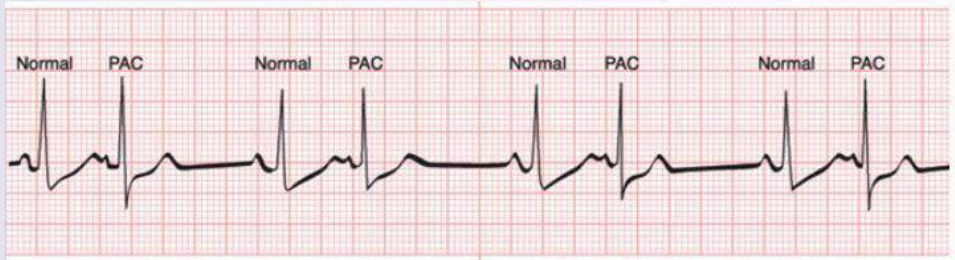
Trigeminal



Quadrigeminal

Q

Premature Atrial Complexes

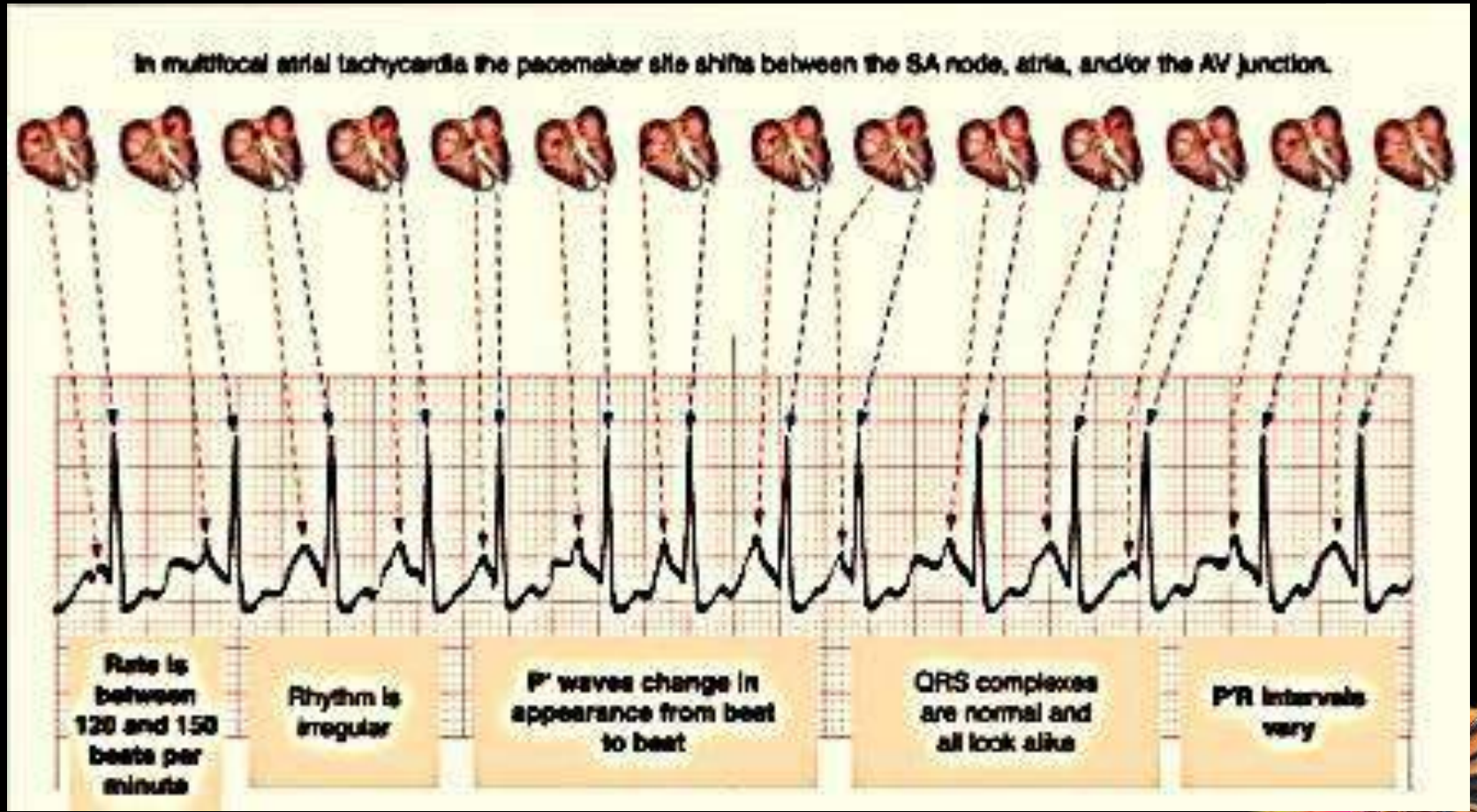


Bigeminal

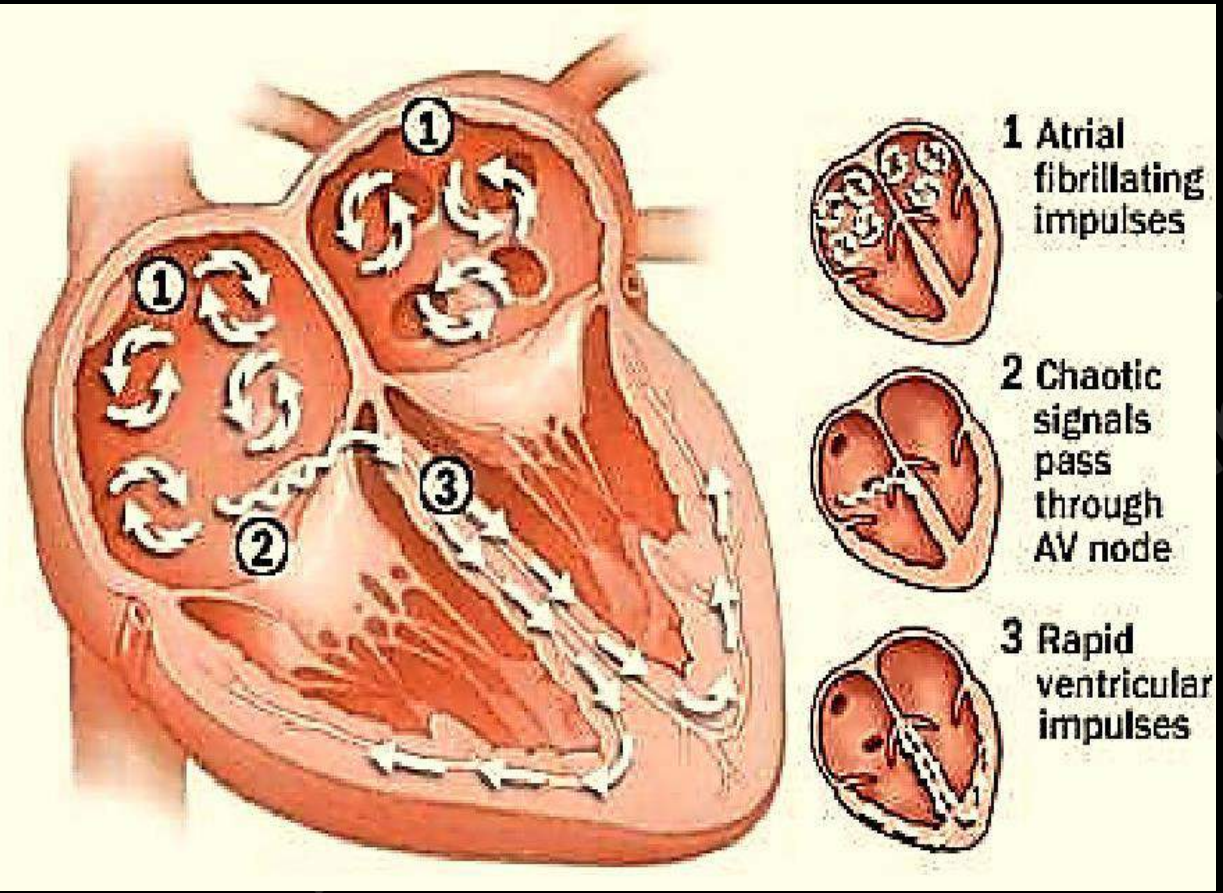
Trigeminal

Quadrigeminal

Q


In multifocal atrial tachycardia the pacemaker site shifts between the SA node, atria, and/or the AV junction.
Rate is between 120 and 150 beats per minute
Rhythm is irregular
P' waves change in appearance from beat to beat
QRS complexes are normal and all look alike
PR intervals vary

Atrial Rhythms

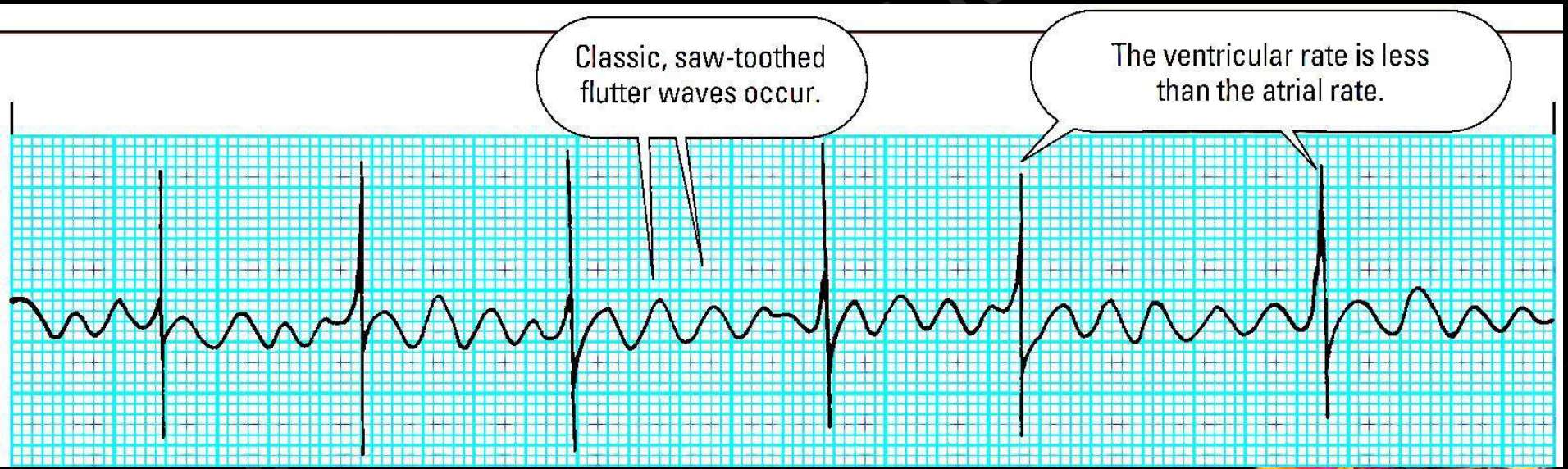


Electrical impulses that originate from the atrium (not from the SA node).

Identifying atrial flutter

This rhythm strip illustrates atrial flutter. Look for these distinguishing characteristics.

- *Rhythm:* Atrial—regular; ventricular—irregular
- *Rate:* Atrial—280 beats/minute; ventricular—60 beats/minute
- *P wave:* Classic saw-toothed appearance
- *PR interval:* Unmeasurable
- *QRS complex:* 0.08 second
- *T wave:* Unidentifiable
- *QT interval:* Unidentifiable
- *Other:* None



S 60 B 86 C 47

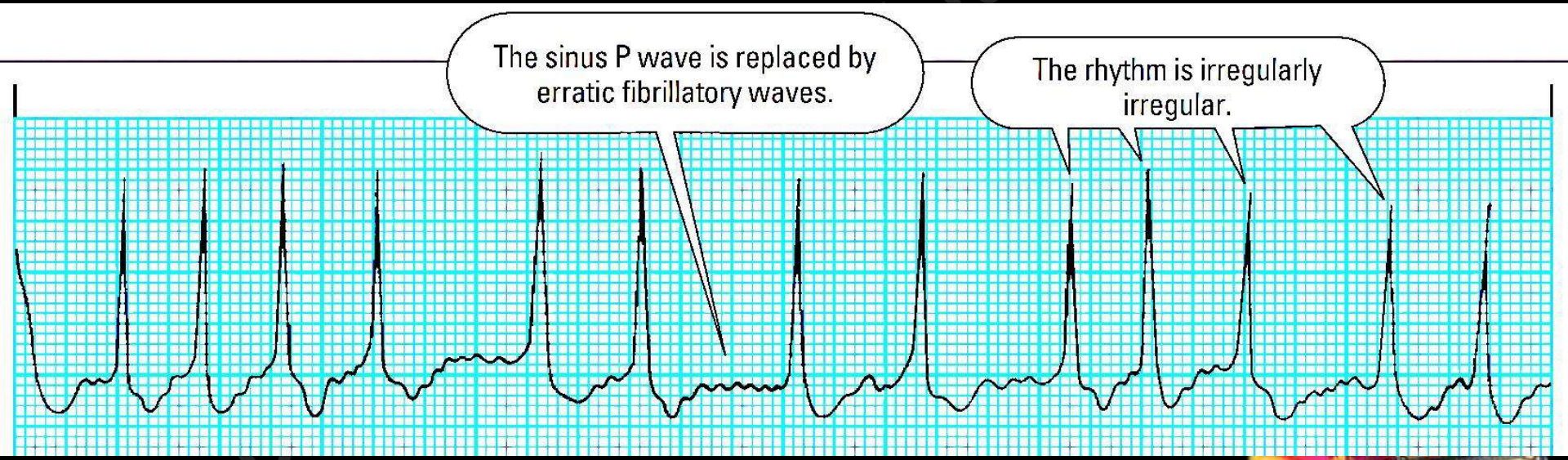
Atrial fibrillation

Atrial fibrillation → absence of P waves and
an irregular ventricular response.

When several ectopic sites in the atria fire impulses, depolarization can't spread in an organized manner

Small sections of the atria are activated individually, which results in the atrial muscle quivering instead of contracting.
On an ECG, you'll see uneven baseline f waves rather than clearly distinguishable P waves.

- *Rhythm:* Irregularly irregular
- *Rate:* Atrial—indiscernible; ventricular—130 beats/minute
- *P wave:* Absent; replaced by fine fibrillatory waves
- *PR interval:* Indiscernible
- *QRS complex:* 0.08 second
- *T wave:* Indiscernible
- *QT interval:* Unmeasurable
- *Other:* None



That fabulous filter

The AV node protects the ventricles from the 400 to 600 erratic atrial impulses that occur each minute

by acting as a filter and blocking some of the impulses.

The atrial rate is almost indiscernible but is usually greater than 400 beats/minute.
The ventricular rate usually varies from 100 to 150 beats/minute but can be lower.

That fabulous filter

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The ventricular rate usually varies from 100 to 150 beats/minute but can be lower.

When the ventricular response rate is below 100, atrial fibrillation is considered controlled.
When it exceeds 100, the rhythm is considered uncontrolled.

Atrial fibrillation is called *coarse* if the f waves are pronounced
and *fine* if they aren't clear f waves
you may find that the radial pulse rate is slower than the apical rate.
That's because, unlike the stronger contractions,
the weaker contractions of the heart don't produce a palpable peripheral pulse

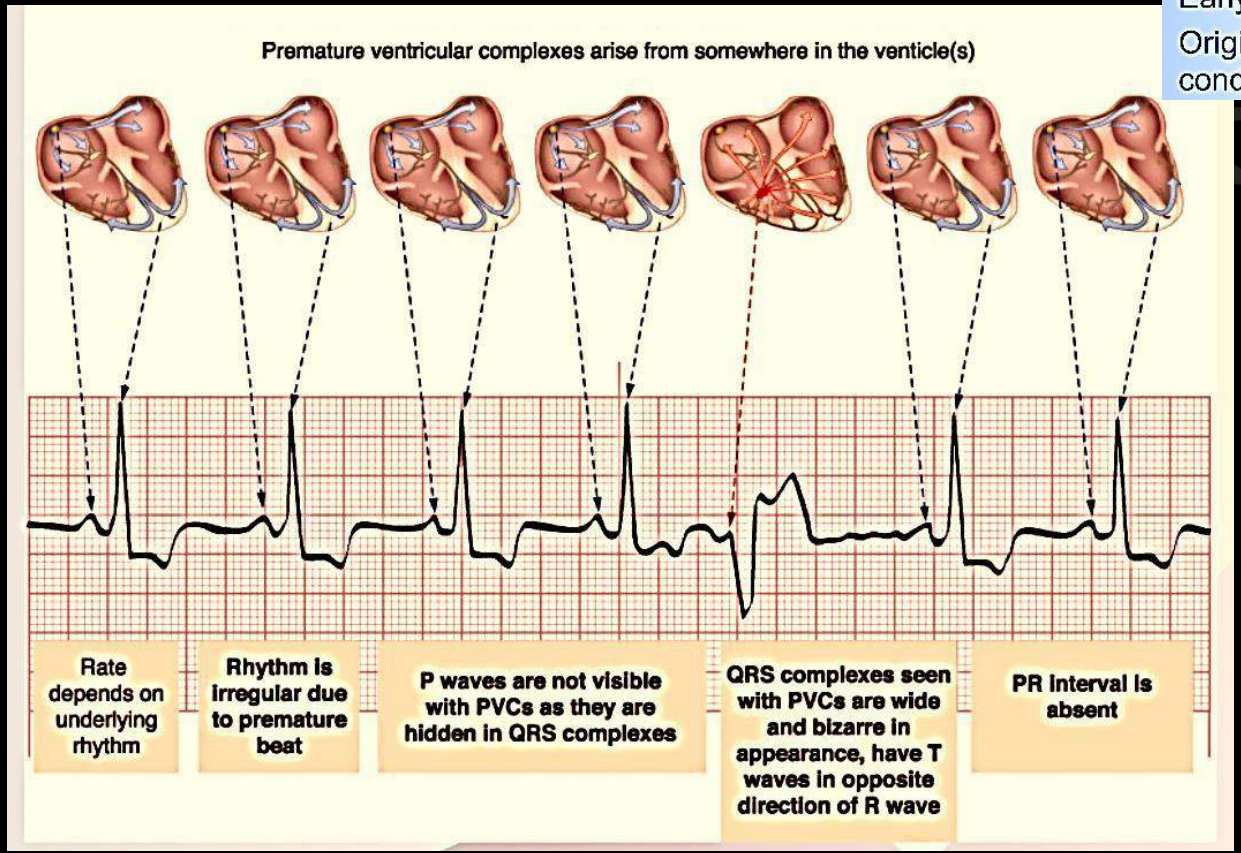
PVC
Premature Ventricular Contraction
or
Ventricular Ectopic

QRS
Wide
T opposite direction of R wave
Often
premature

Premature Ventricular Complexes (PVCs)

Early ectopic beats that interrupt the normal rhythm

Originate from an irritable focus in the ventricular conduction system or muscle tissue



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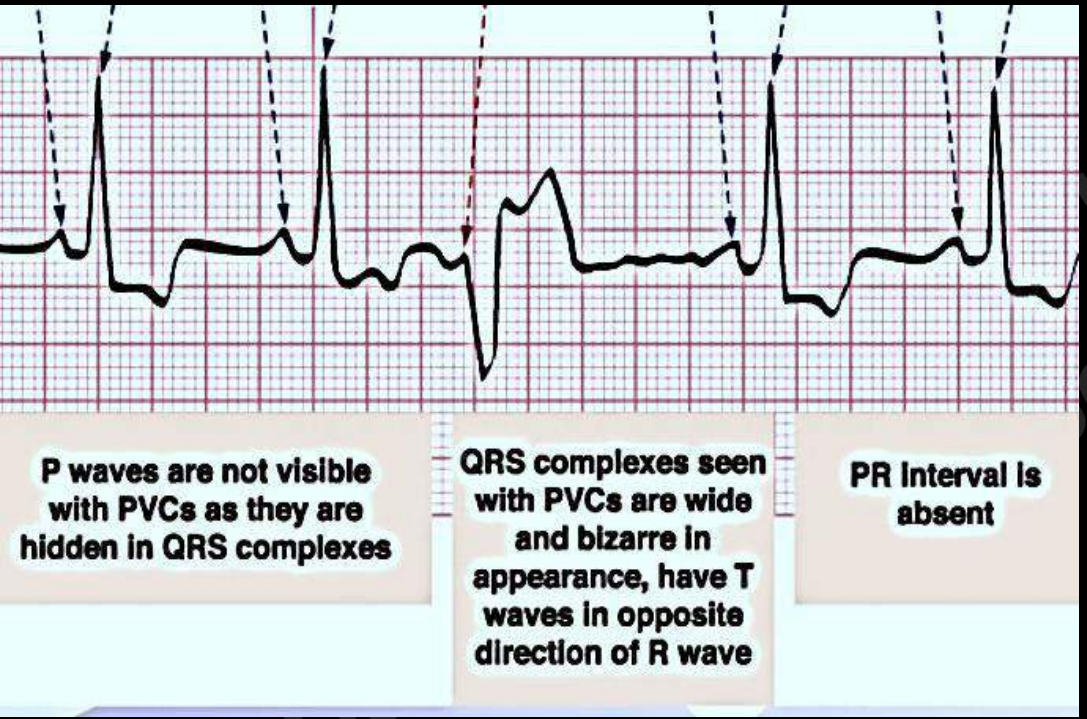
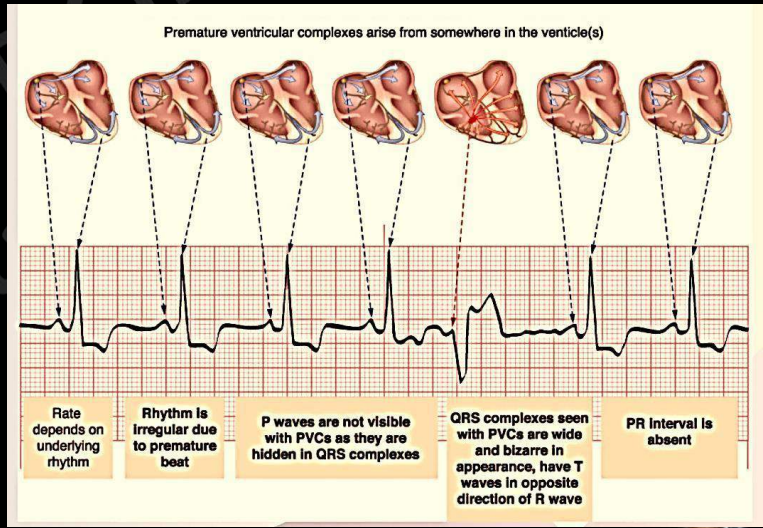
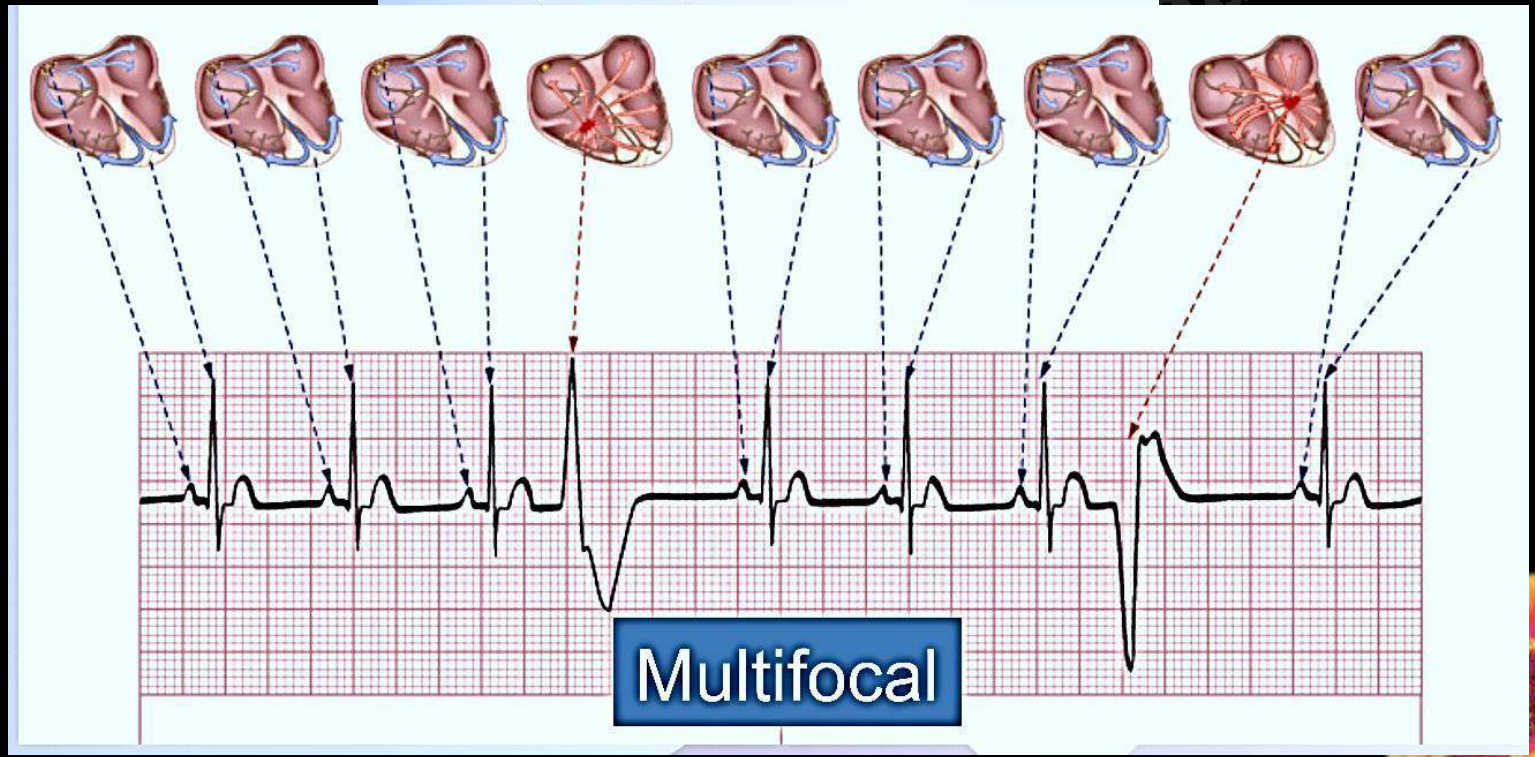




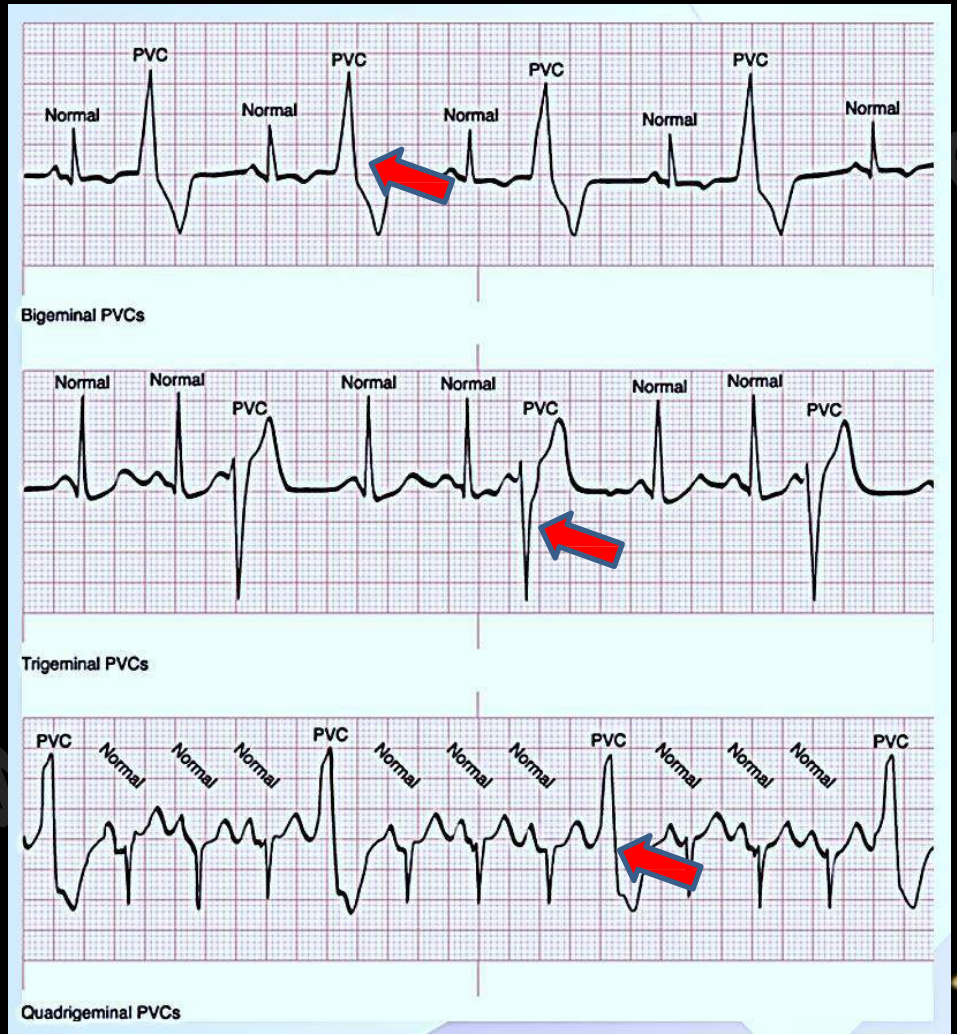
Premature Ventricular Complexes

PVCs that look the same are called *uniform* (unifocal)

PVCs that look different from each other are called *multiform* (multifocal)



Premature Ventricular Complexes

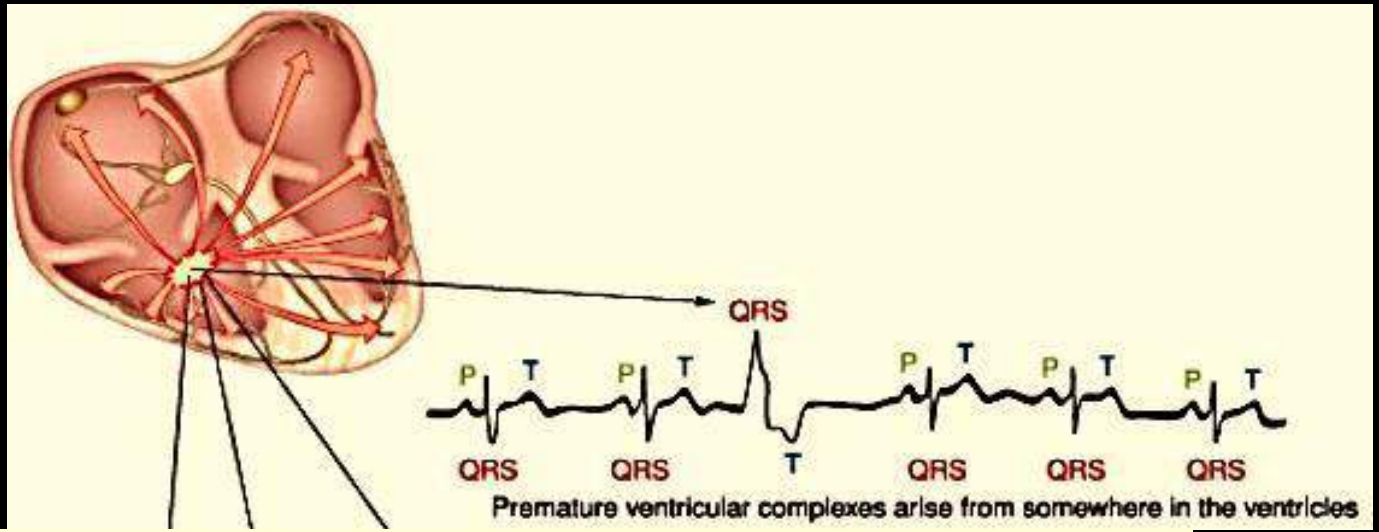


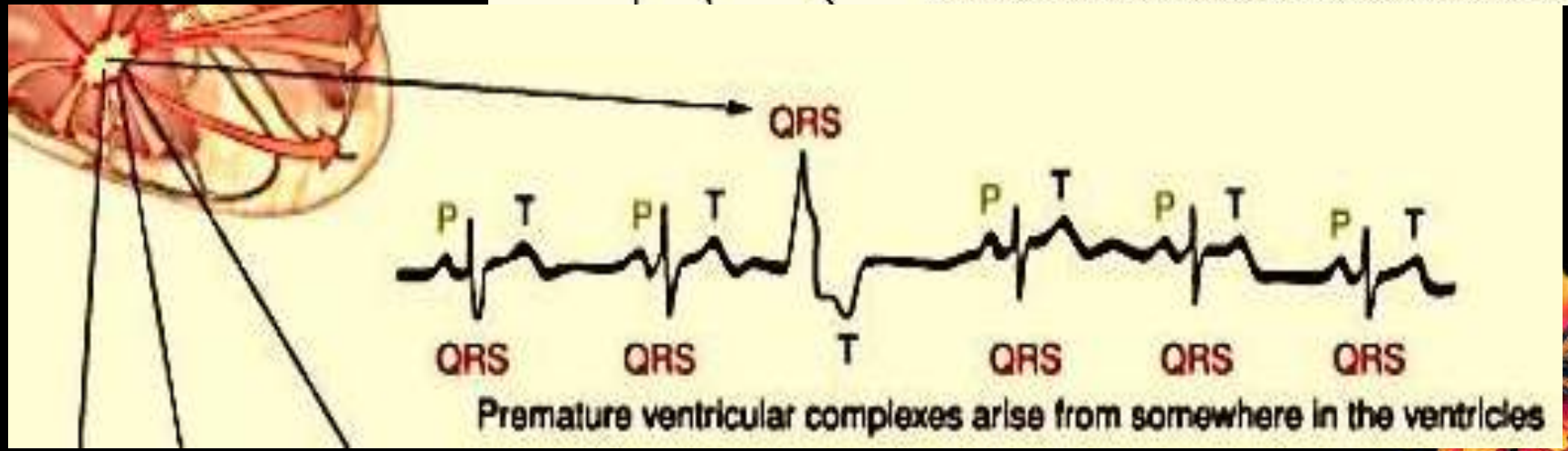
Premature Ventricular Complexes

- Two PVCs in a row are called a *couplet* and indicate extremely irritable ventricles

Ventricular Dysrhythmias

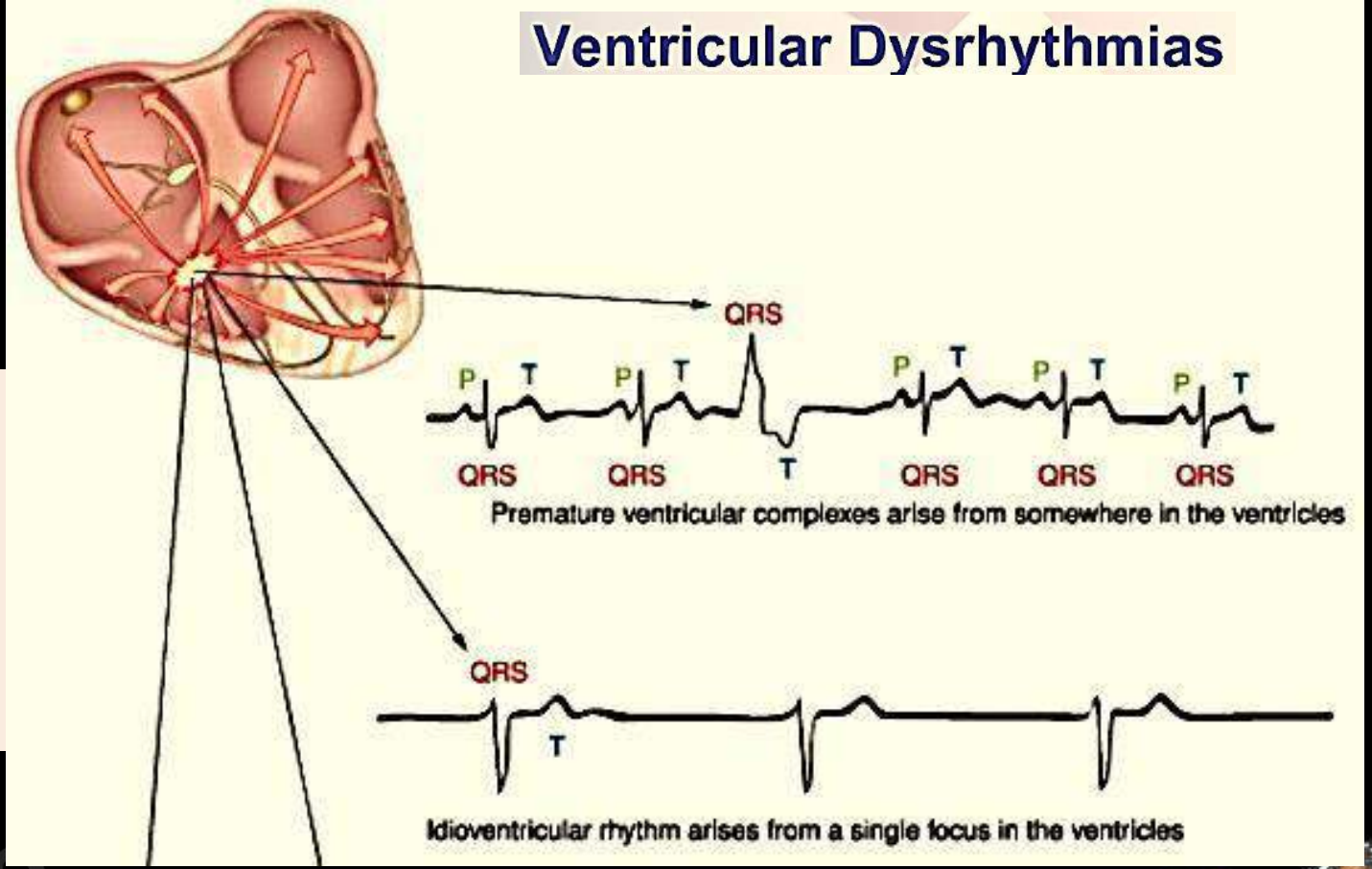
- Premature ventricular complex (PVC)





Ventricular Dysrhythmias

- Premature ventricular complex (PVC)
- Ventricular escape complexes or rhythm



Ventricular Dysrhythmias

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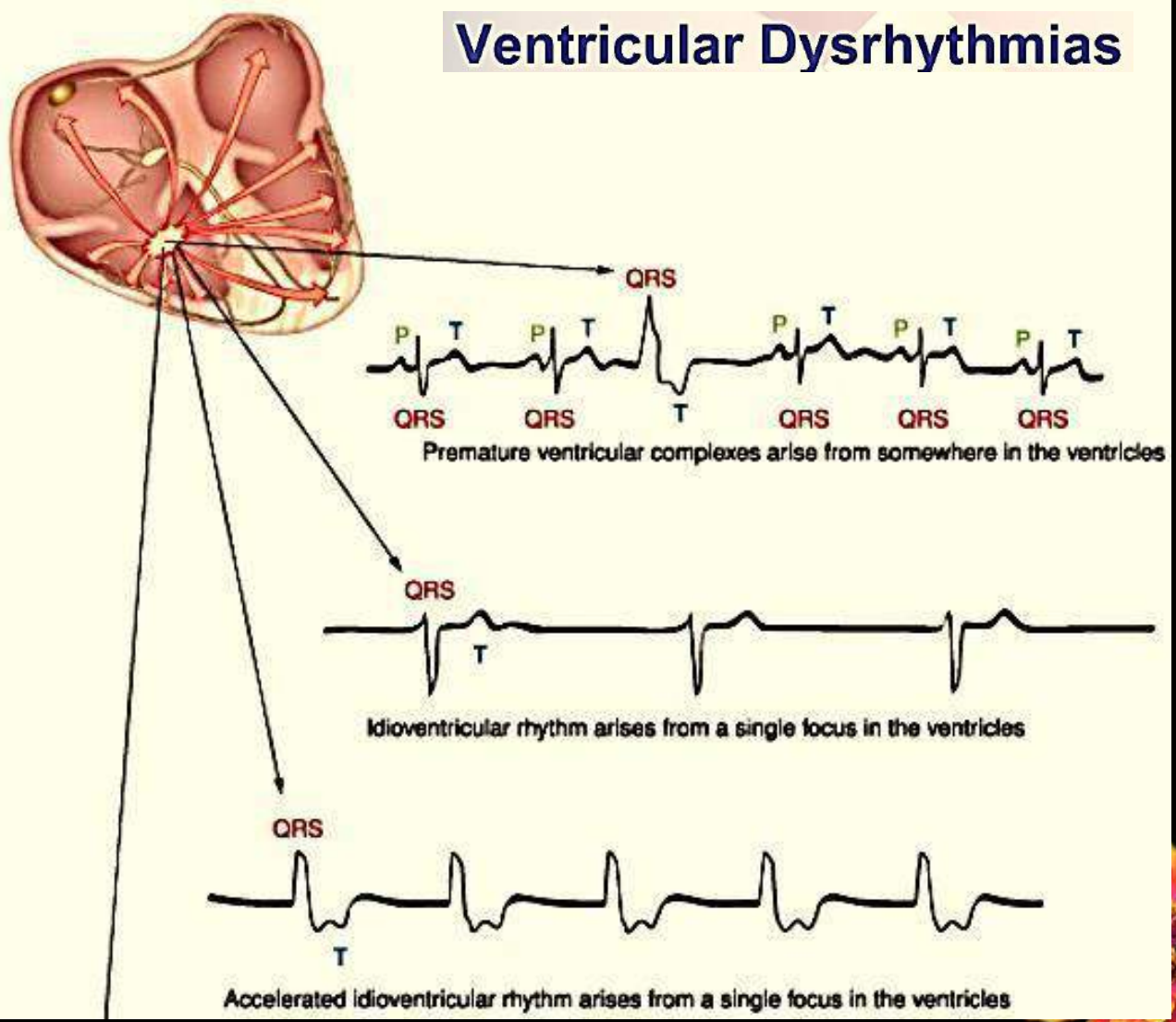
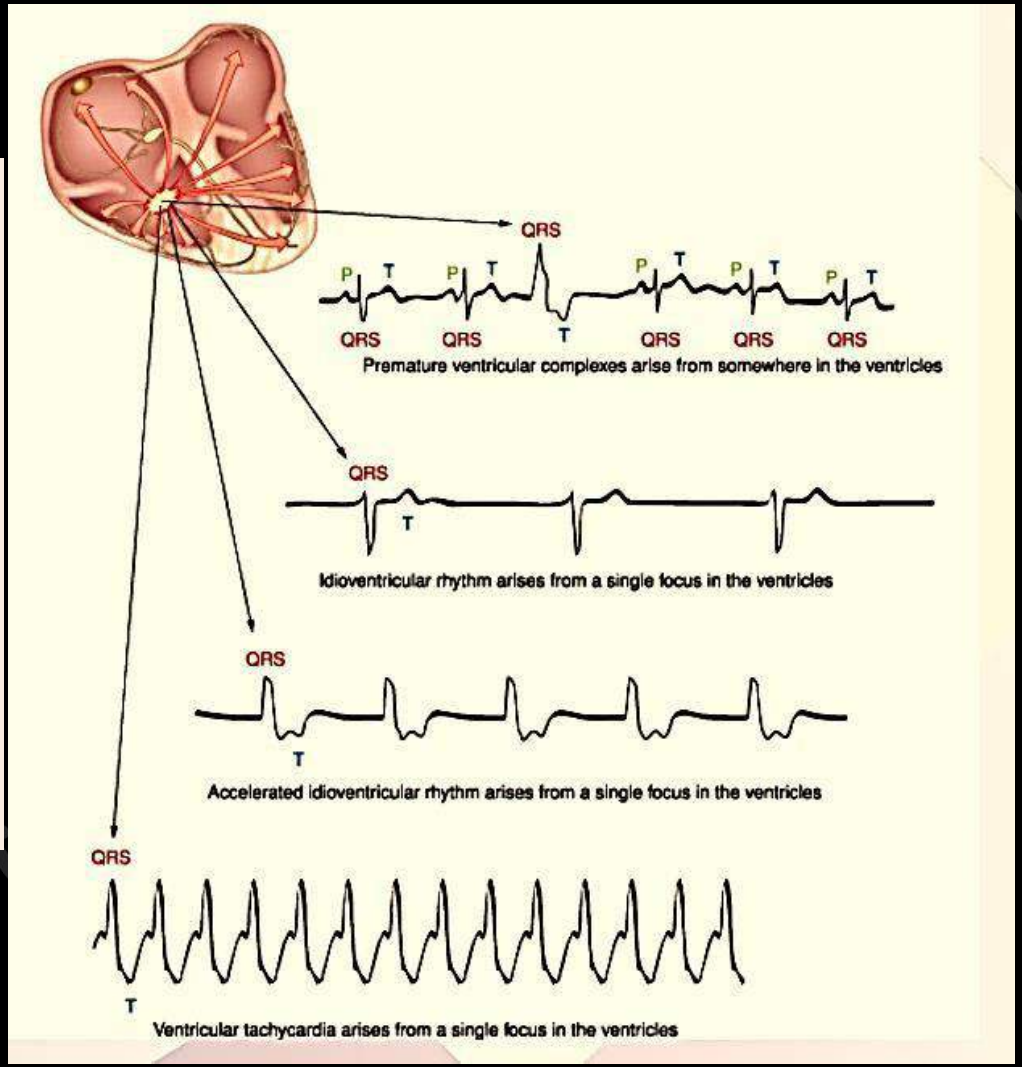
- Ventricular escape complexes or rhythm



Ventricular Dysrhythmias

- Premature ventricular complex (PVC)
- Ventricular escape complexes or rhythm
- Ventricular tachycardia
- Ventricular fibrillation
- Asystole



Ventricular Dysrhythmias

- Premature ventricular complex (PVC)
- Ventricular escape complexes or rhythm
- Ventricular tachycardia
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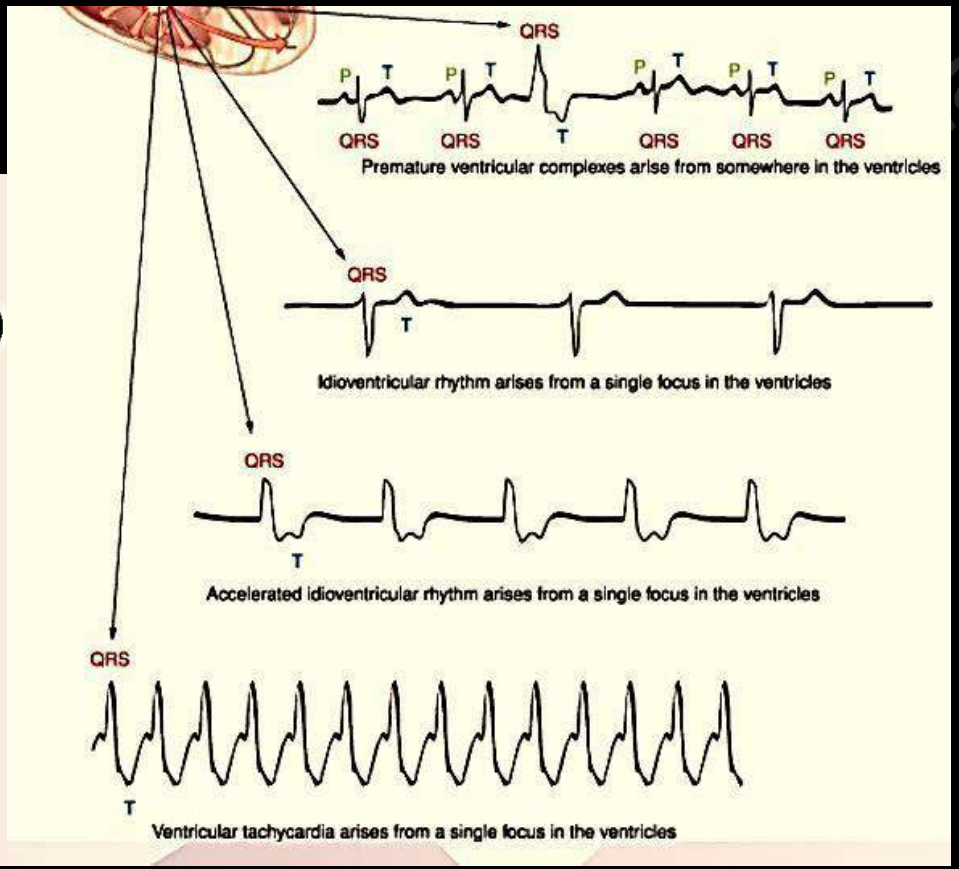
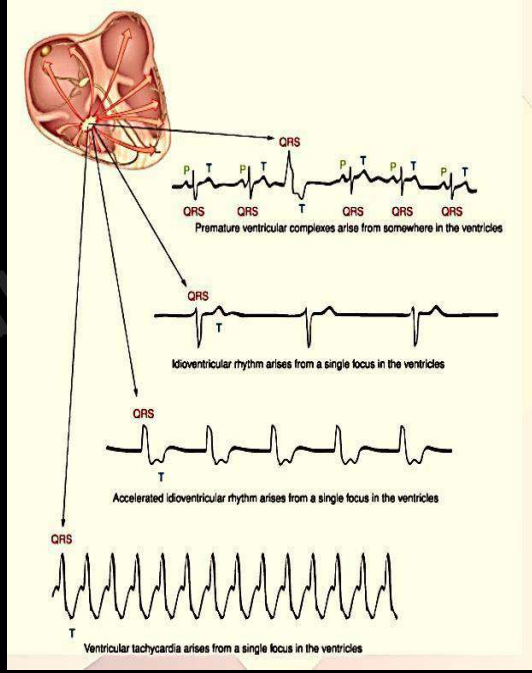
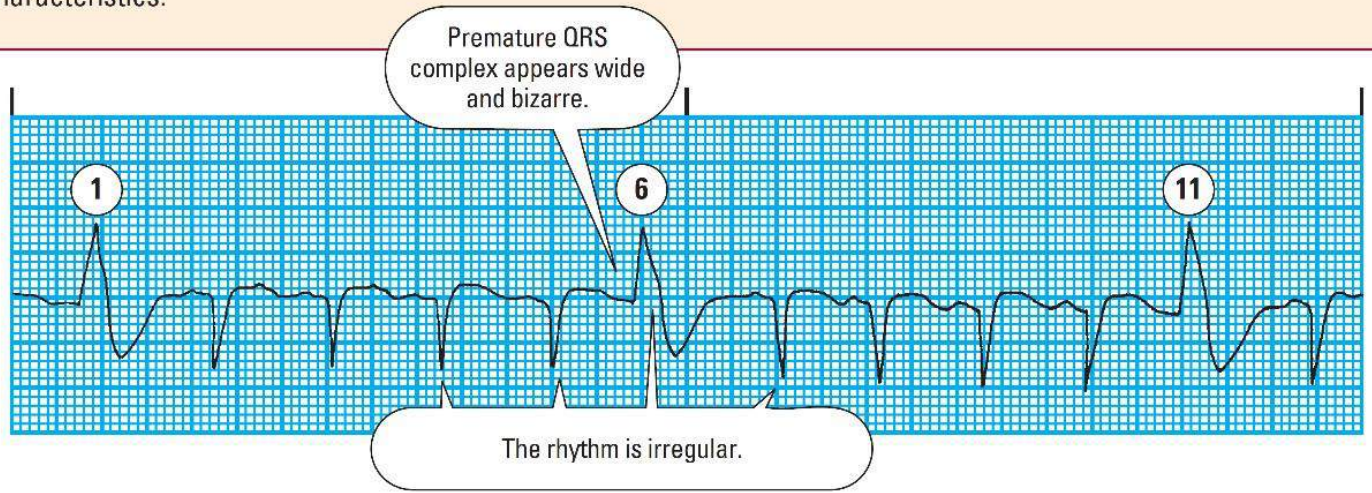
- Asystole





Identifying PVCs

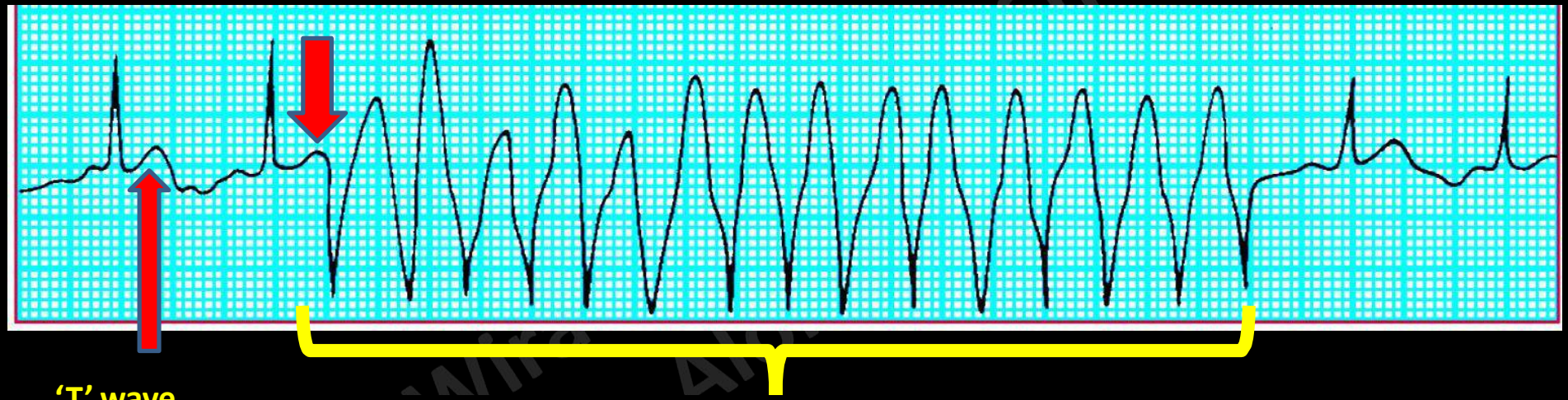
This rhythm strip illustrates premature ventricular contraction (PVC) on beats 1, 6, and 11. Look for these distinguishing characteristics.



- *Rhythm:* Irregular
- *Rate:* 120 beats/minute
- *P wave:* Absent with PVC, but present with other QRS complexes
- *PR interval:* 0.12 second in underlying rhythm
- *QRS complex:* Early with bizarre configuration and duration of 0.14 second in PVC; 0.08 second in underlying rhythm
- *T wave:* Normal; opposite direction from QRS complex with PVC
- *QT interval:* 0.28 second with underlying rhythm
- *Other:* Compensatory pause after PVC

R-on-T phenomenon

In R-on-T phenomenon, the PVC occurs so early that it falls on the T wave of the preceding beat (see highlighted area). Because the cells haven't fully repolarized, ventricular tachycardia or ventricular fibrillation can result.

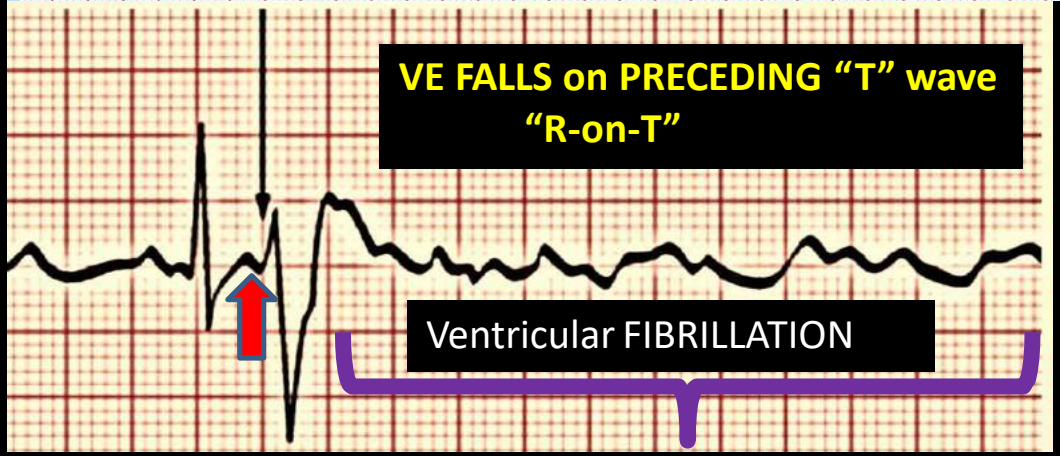


'T' wave

Ventricular TACHYCARDIA
→Very often becomes
→Ventricular FIBRILLATION

Premature Ventricular Complexes

- PVCs occurring on or near the previous T wave (R-on-T PVCs) may precipitate ventricular tachycardia or fibrillation

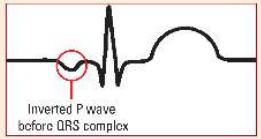


Mixed signals

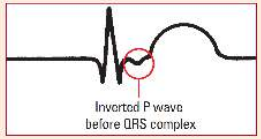
Finding the P wave

When the pacemaker fires in the atrioventricular junction, the impulse may reach the atria or the ventricles first. Therefore, the inverted P wave and the following QRS complex won't have a consistent relationship. These rhythm strips show the various positions the P wave can take in junctional rhythms.

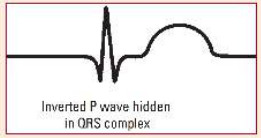
Atria first
If the atria are depolarized first, the P wave will occur before the QRS complex.



Ventricles first
If the ventricles are depolarized first, the QRS complex will come before the P wave.



Simultaneous
If the ventricles and atria are depolarized simultaneously, the P wave will be hidden in the QRS complex.

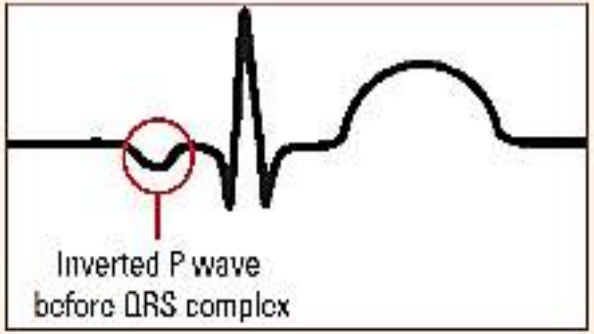


Junctional mimic

Atrial arrhythmias are sometimes mistaken for junctional arrhythmias because impulses are generated so low in the atria that they cause retrograde depolarization and inverted P waves. Looking at the PR interval will help you determine whether an arrhythmia is atrial or junctional.

An arrhythmia with an inverted P wave before the QRS complex and a normal PR interval (0.12 to 0.20 second) originated in the atria. An arrhythmia with a PR interval less than 0.12 second originated in the AV junction.

Atria first
If the atria are depolarized first, the P wave will occur before the QRS complex.



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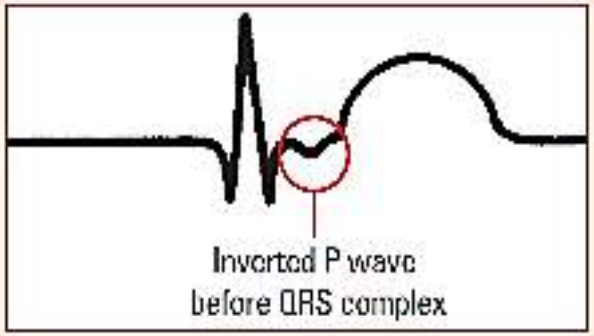

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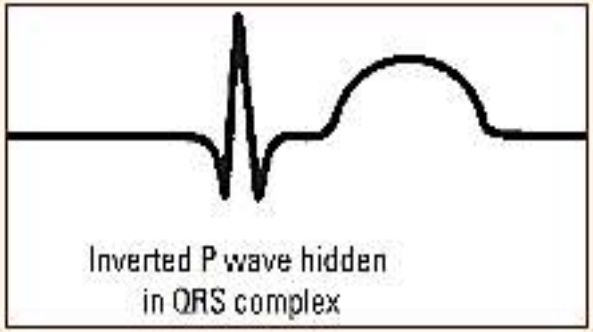
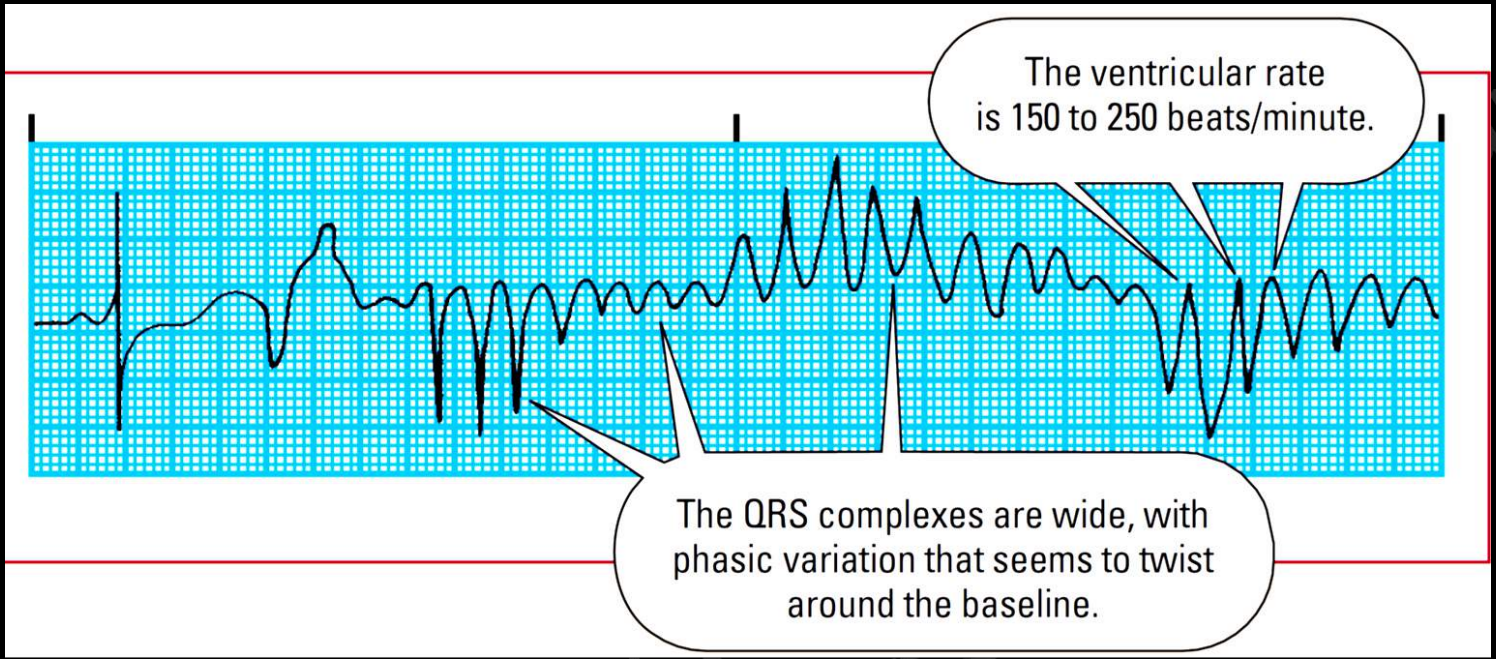
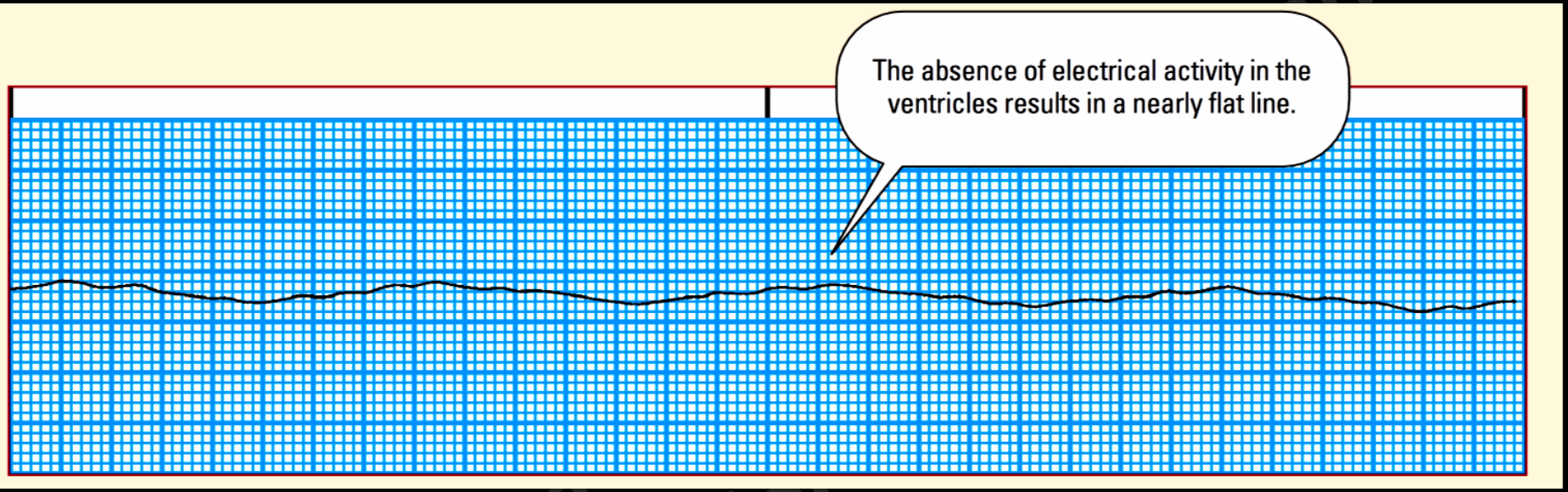
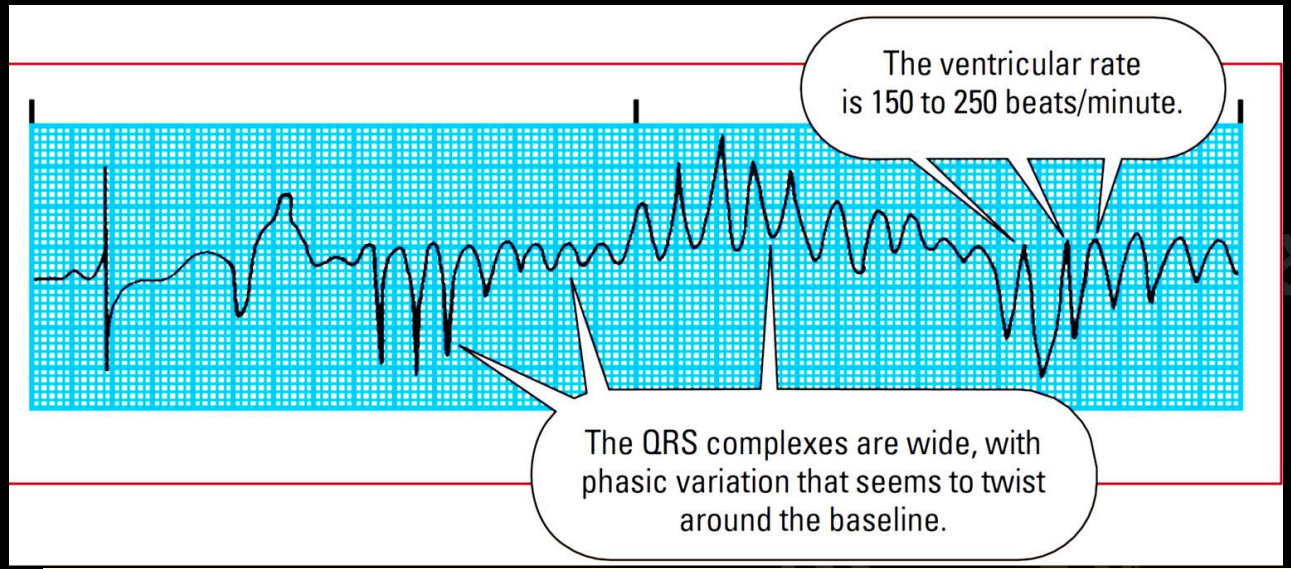


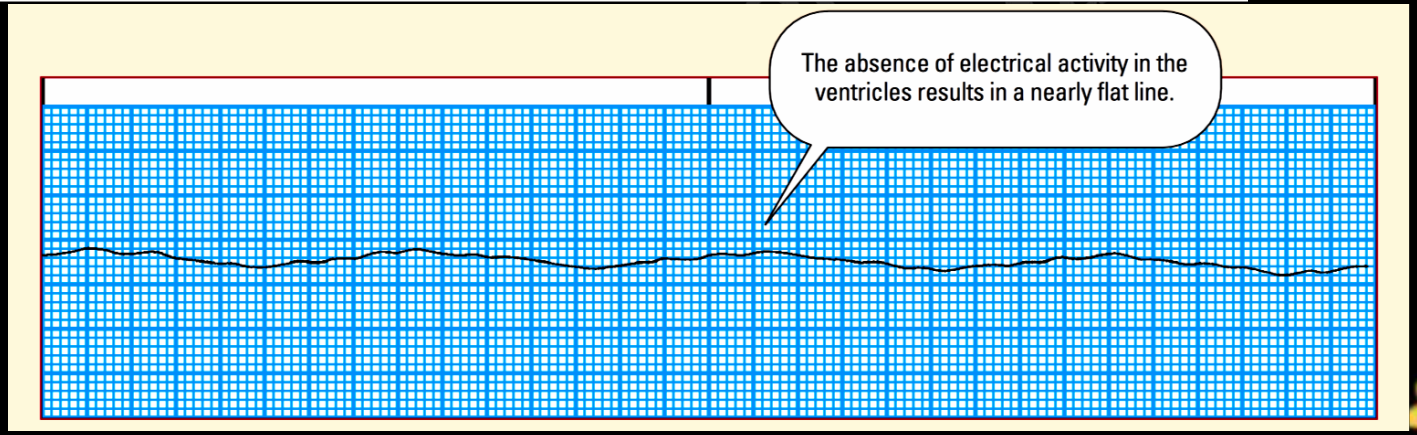


"Torsades de Pointes" = pronounced

" ***TORSA de PUA***" the 'turning of the Points'




The ventricular rate is 150 to 250 beats/minute.
The QRS complexes are wide, with phasic variation that seems to twist around the baseline.


The absence of electrical activity in the ventricles results in a nearly flat line.

Sinus bradycardia occurs on an ECG when there is a normal upright P wave in lead II — sinus P wave — preceding every QRS complex with a ventricular rate of less than 60 beats per minute.

Causes:-

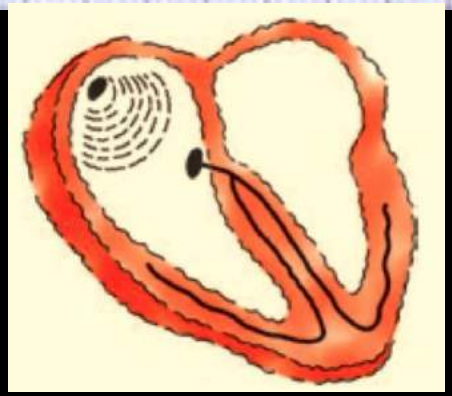
AV blocking medications (beta-blockers, nondihydropyridine calcium channel blockers, digoxin)
Heightened vagal tone (i.e. well-trained athlete)
Hypothyroidism
Obstructive sleep apnea
Sick sinus syndrome
Hypoglycemia
Hypothermia

Sinus tachycardia →

a normal upright P wave in lead II preceding every QRS complex,

→**current** is coming from the sinus node [and not elsewhere in the atria,]

with **an atrial rate of greater than 100 beats per minute.**



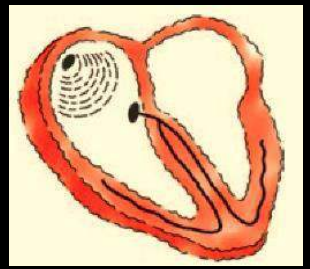
The ventricular rate (look at the QRS complex rate)

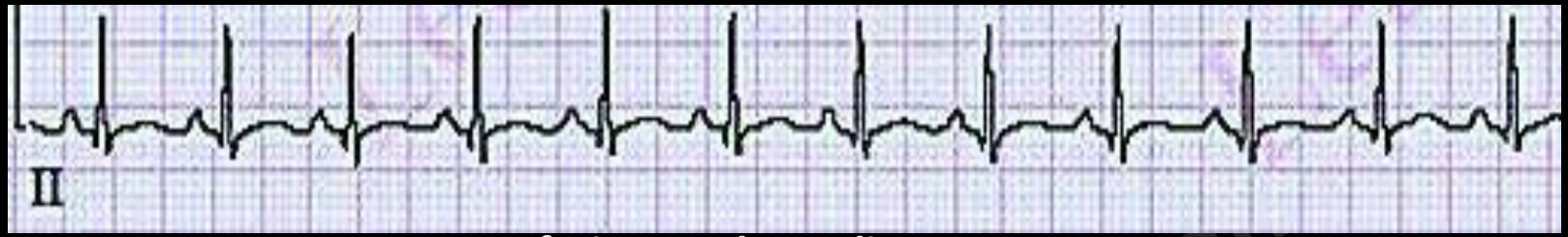
is usually also greater than 100 bpm

because, in most cases, the P wave conducts through the atrioventricular node to the ventricles to produce a QRS complex in a 1:1 fashion.

Tachycardia

Bradycardia





Causes of sinus tachycardia

Exercise
Anemia
Dehydration or shock
Fever/sepsis/infection
Hypoxia
Chronic pulmonary disease

Decompensated congestive heart failure
Medications/stimulants
Hyperthyroidism
Pheochromocytoma
Pulmonary embolus

Ectopic atrial rhythms

[including atrial tachycardia, multifocal atrial tachycardia and junctional rhythms]

all have ***P waves that are not of sinus ORIGIN***

ECTOPIC atrial rhythms occur→ when a site outside of the sinus node, but within the atria, [***and → faster than the sinus node***.]

P wave would not have its normal sinus appearance — that is, upright in lead II and biphasic in V1.

However, it would have a different **SHAPE** depending on exactly where it originates.

This is referred to as an "ectopic atrial rhythm" or "ectopic P wave."

Thank you