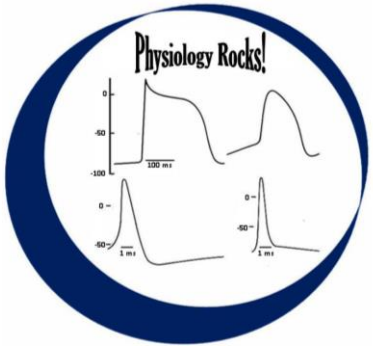
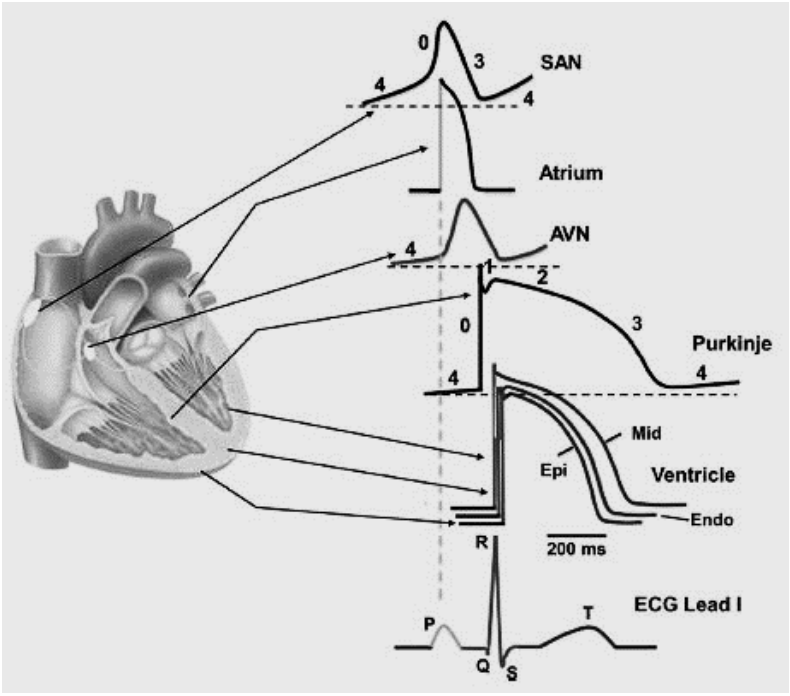
Lecture 24
Introduction to Electrocardiography





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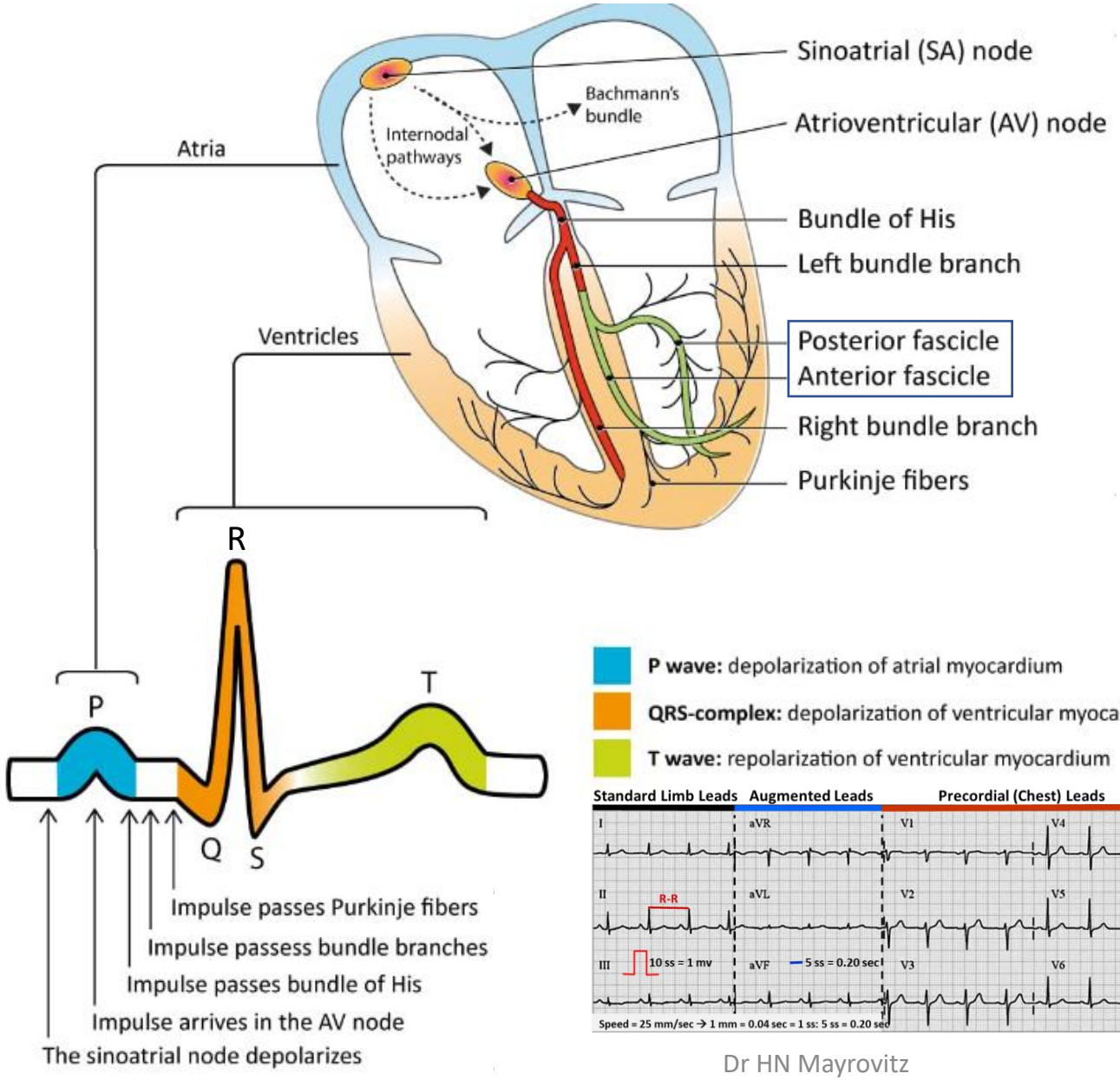
EKG: Introduction and Overview

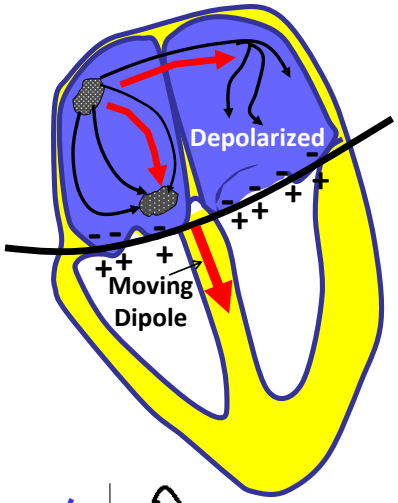


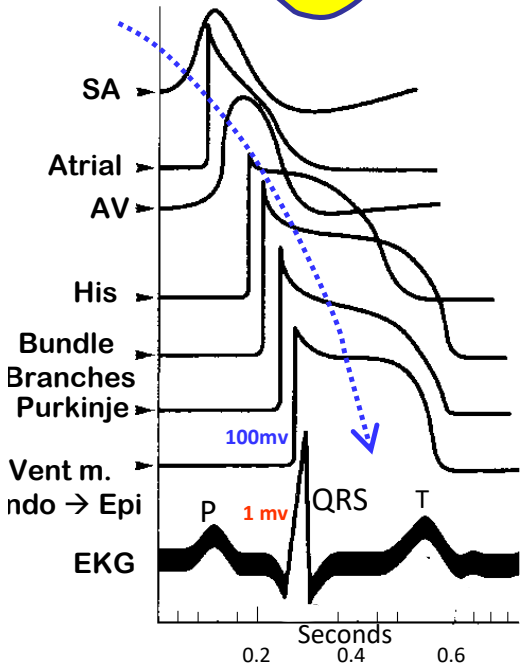
P wave: depolarization of atrial myocardium

QRS-complex: depolarization of ventricular myocardium

T wave: repolarization of ventricular myocardium

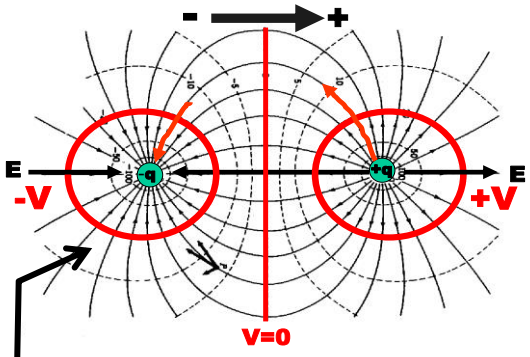
Moving waves of changing electrical activity are EKG source

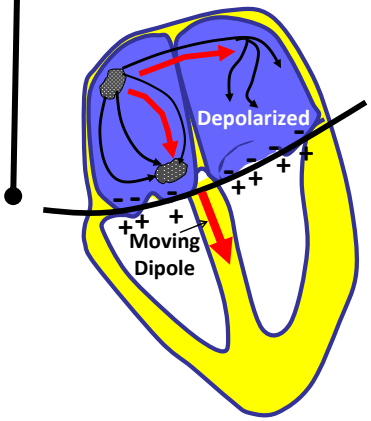




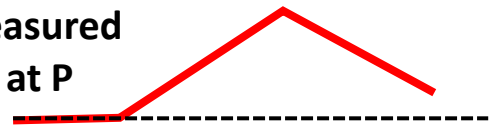
Moving Dipole Causes Voltage Change at a Distance

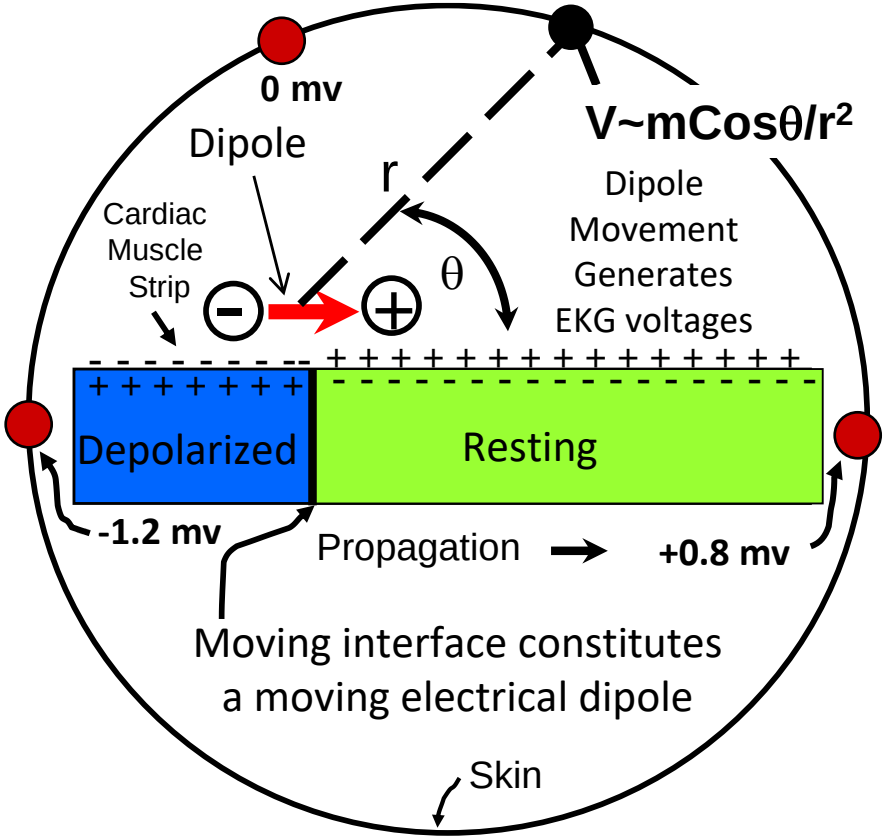
- Dipole: Equal but opposite separated charge
- Moving wave of cardiac depolarization viewed as a moving dipole
- As long as its moving it generates a voltage
- Sensed (measured) voltage is the EKG (ECG)



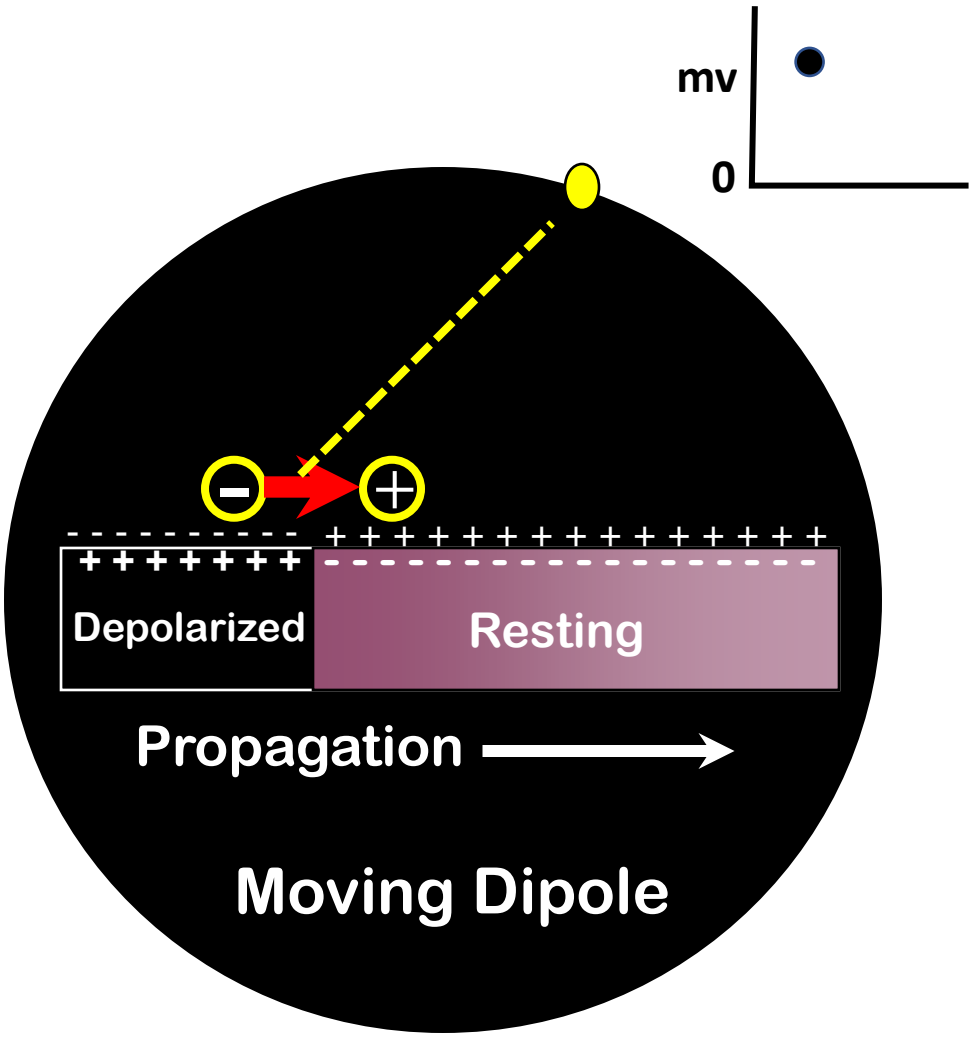


Voltage changes measured at P

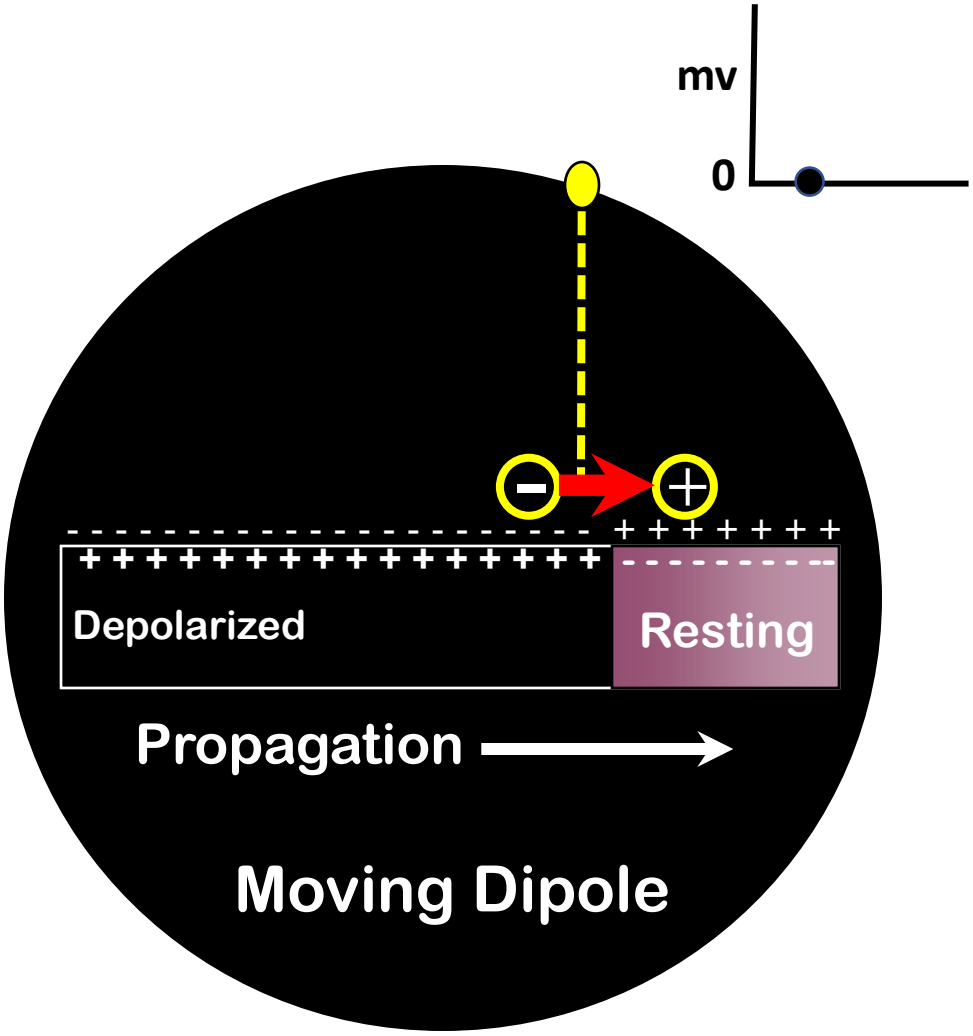




Moving Dipole Produces Voltage Change at a Distance

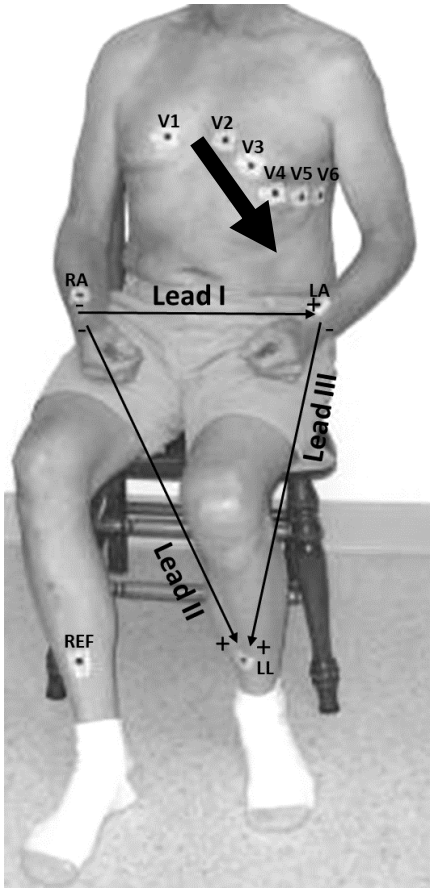


Moving Dipole → Voltage Change at a Distance



Measuring the EKG

Leads, Axes & Einthoven Frontal Plane



Lead axes ("sense") standardized
+ direction = (-) to (+); tail-to-tip
Dipole projection in this sense causes upward EKG deflection

Right Arm
RA

LA

Lead I

MEA

Lead II

Lead III

Pairs of electrodes constitute LEADS

Einthoven's Triangle
Set-up to record (+) deflection for normal QRS Vector (MEA)
Set up as: II = I + III

MEA = mean electrical axis
Average direction of wave of depolarization during the QRS complex

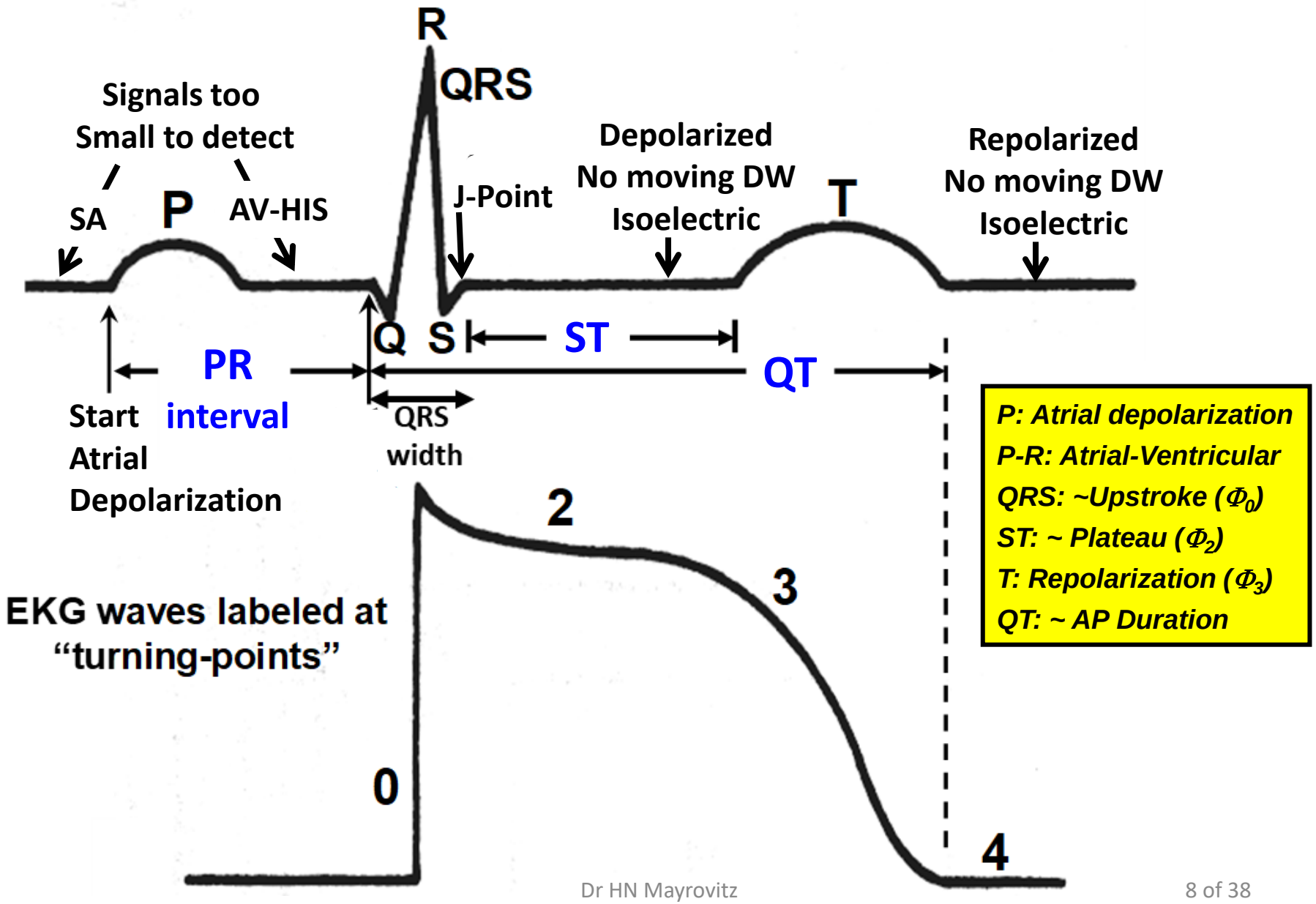
Lead selector and amplifier

Chart Recorder

Left Leg
LL

Reference Ground Electrode

EKG Components and Relationship to AP



EKG Components and Relationship to AP

Normal ranges (s)

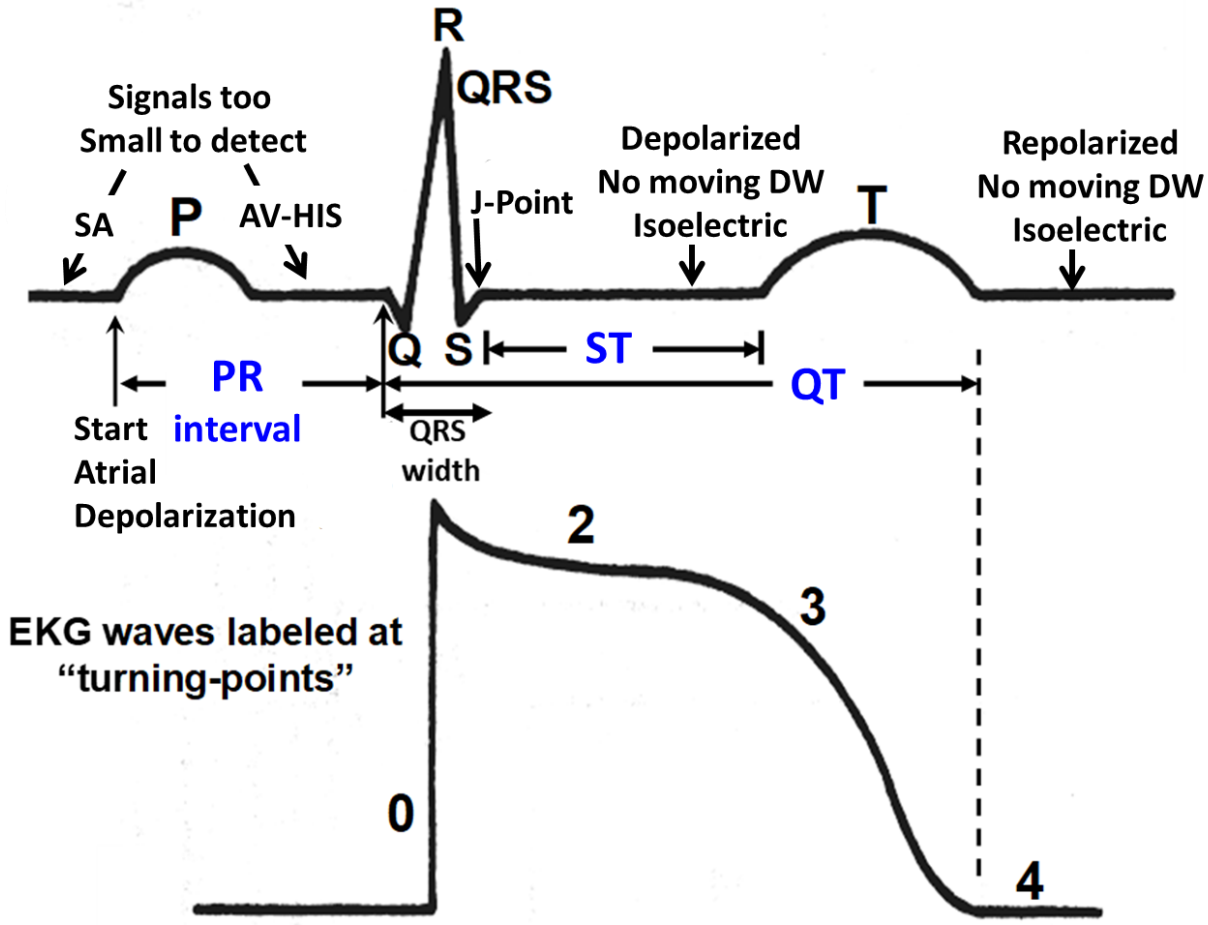
PR:	0.12 – 0.20	3-5 ss
QRS:	0.06 – 0.12	1.5-3 ss
QTc:	≤ 0.40 – 0.44	10-11 ss

QTc (Corrected QT interval)

- QT measured depends on HR
- QT decreases increased HR
- So normalize to HR=60
- QTc = QTm / sqrt(RR)

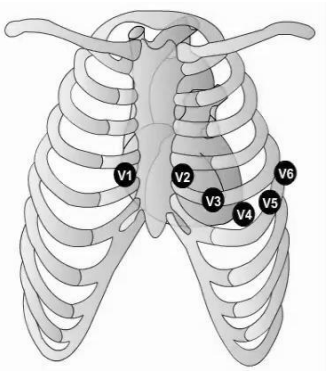
Measured	HR	Corrected
0.40	60	0.40
0.40	80	0.46
0.40	100	0.52

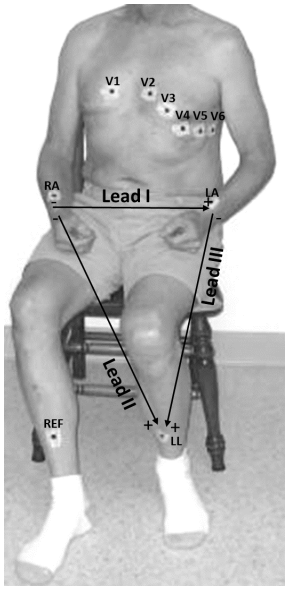
Long QT (syndrome) increased risk of sudden death if:
Male QTc > 0.45
Female QTc > 0.47

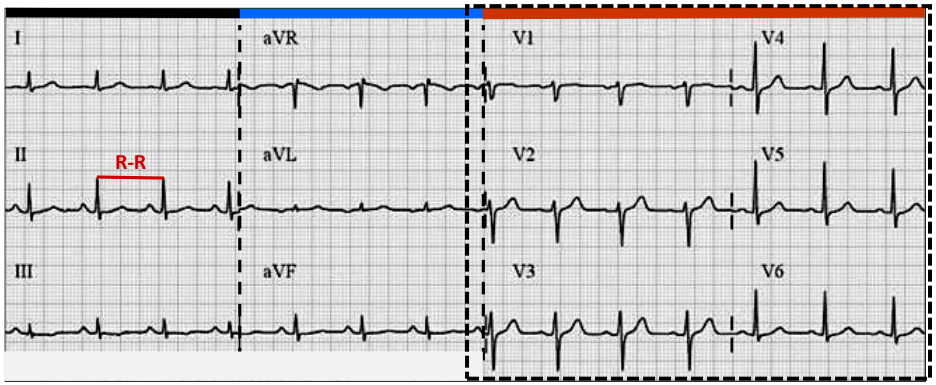


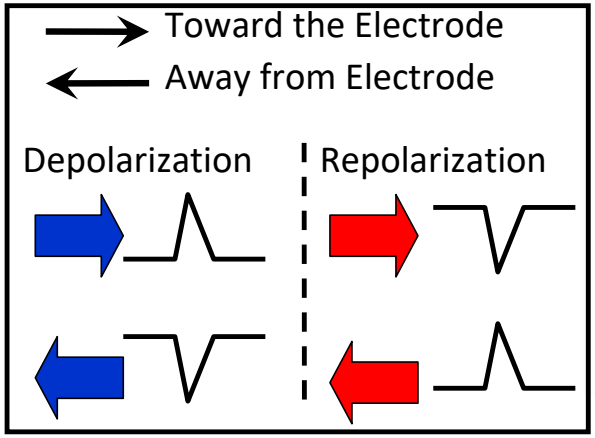
R-wave → 1st positive deflection
S-wave → a negative deflection that follows an R-wave
Q-wave → if 1st deflection of QRS complex is negative = Q-wave

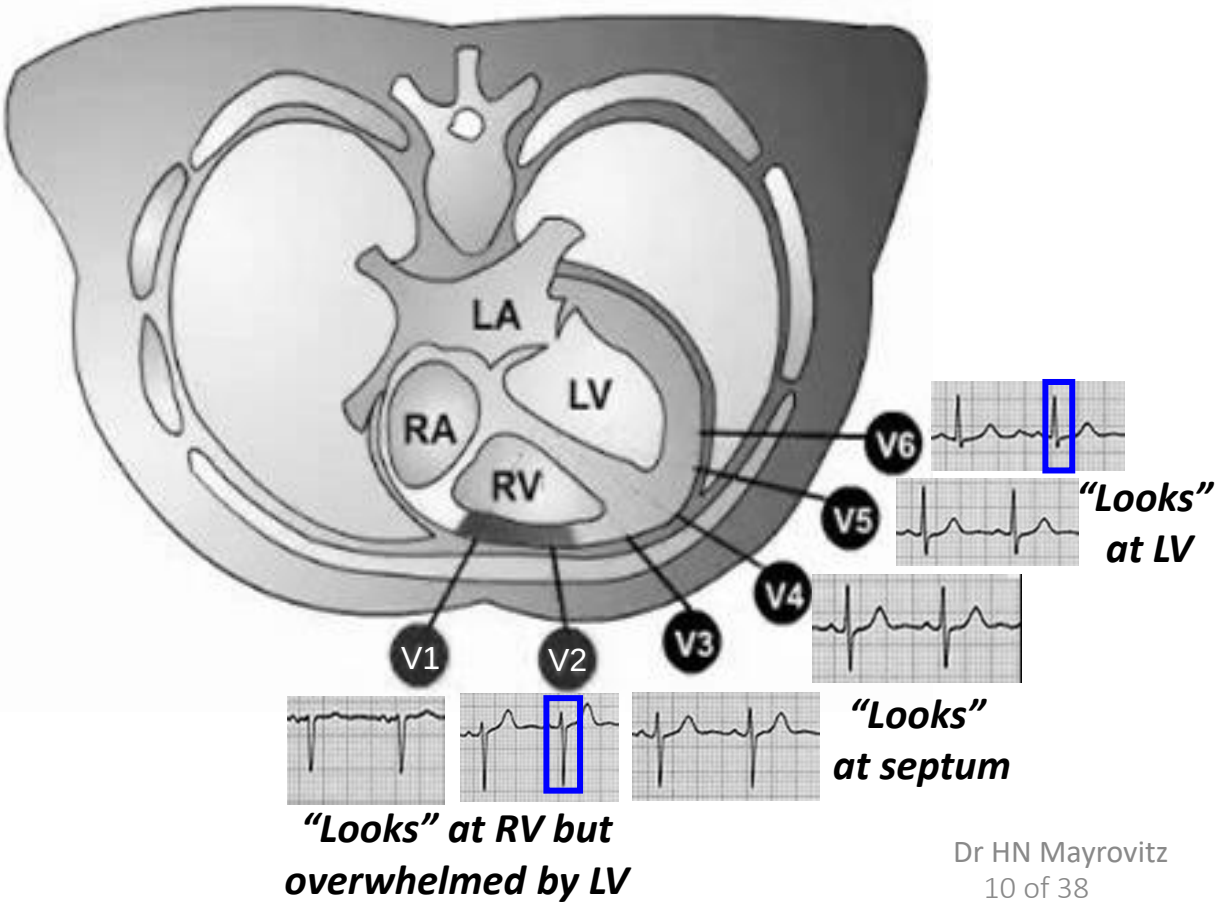
Chest (Precordial) Leads: EKG Deflections



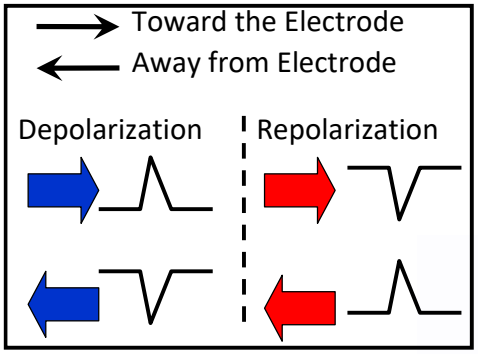






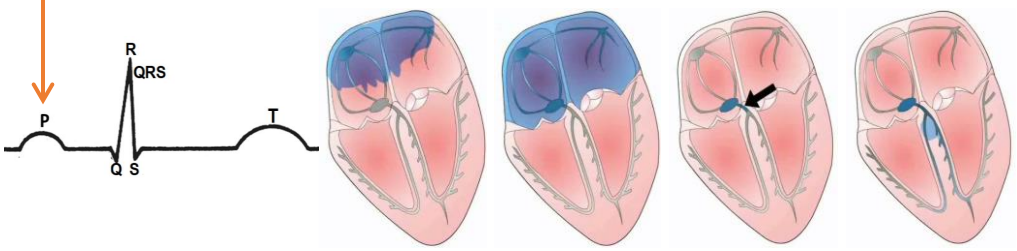


EKG Wave Naming & Depolarization-Repolarization

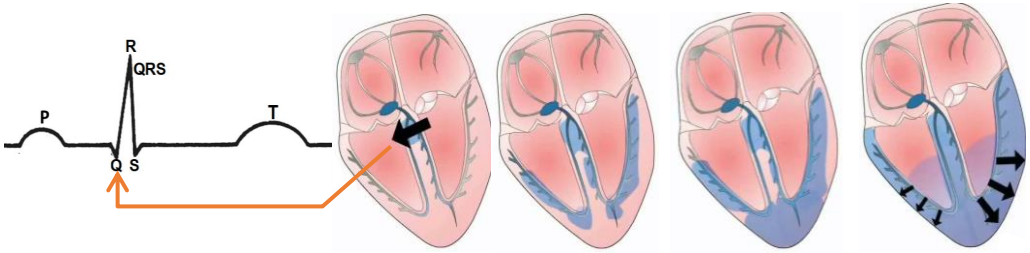


QRS complex Naming

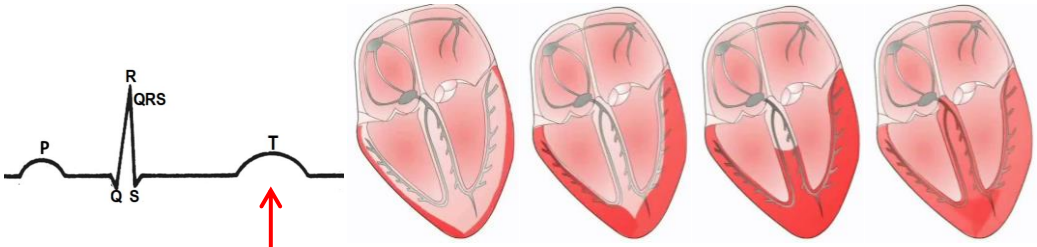
EKG waves labeled at turning point



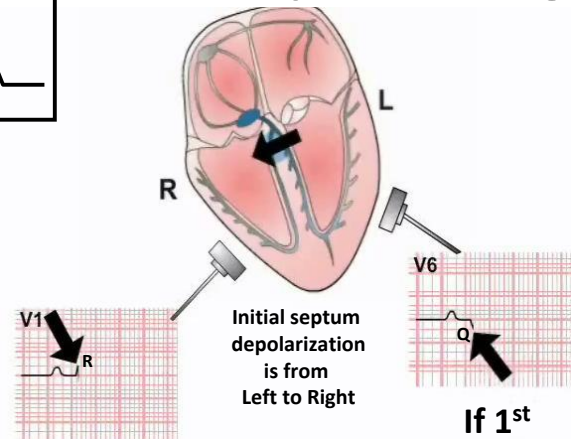
Atrial Depolarization Thru AV → His → Septum



Ventricular Depolarization

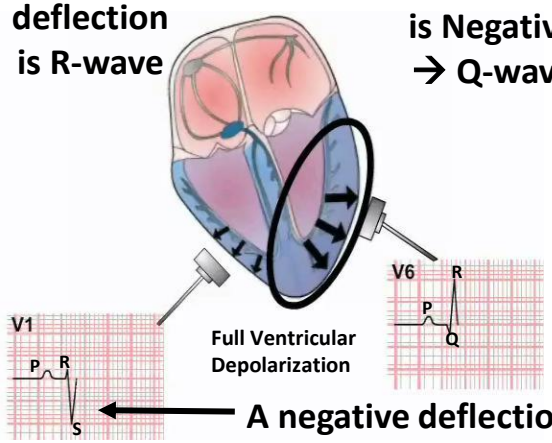


Ventricular Repolarization



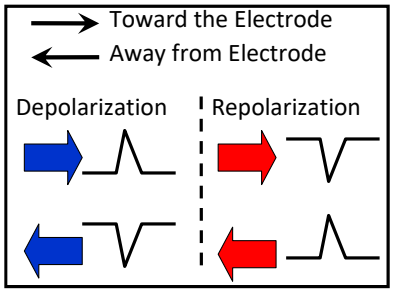
1st positive deflection is R-wave

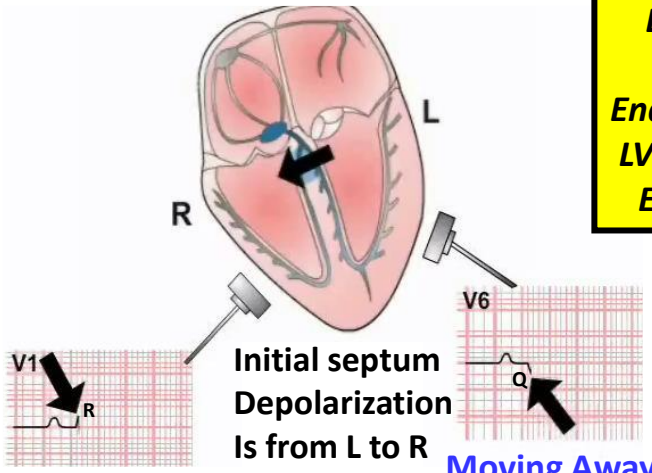
If 1st deflection is Negative → Q-wave



A negative deflection following R-wave is an S-wave

Review: EKG Deflection Patterns



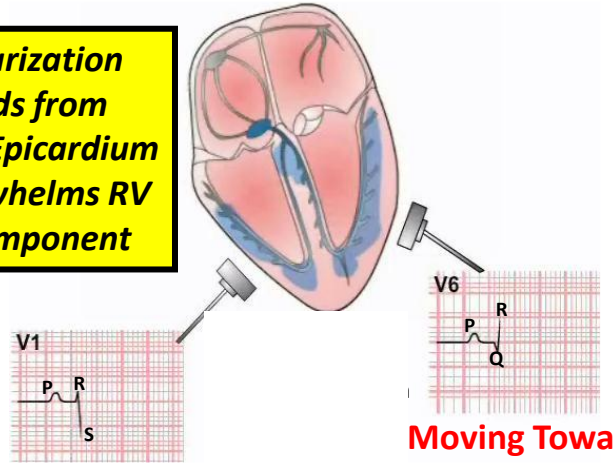


Initial septum Depolarization Is from L to R

Moving Toward This Electrode

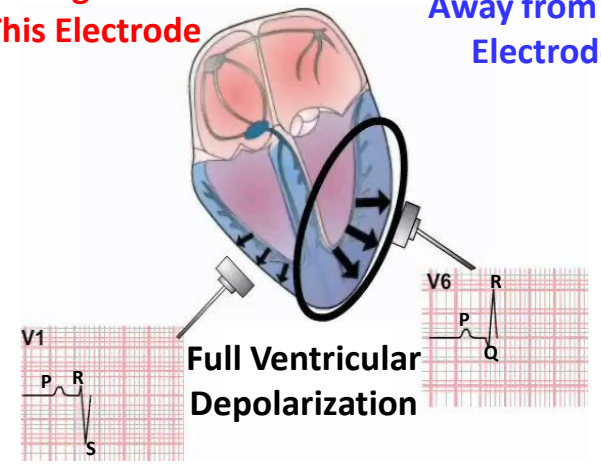
Moving Away Away from this Electrode

Depolarization Spreads from Endo to Epicardium LV overwhelms RV EKG component

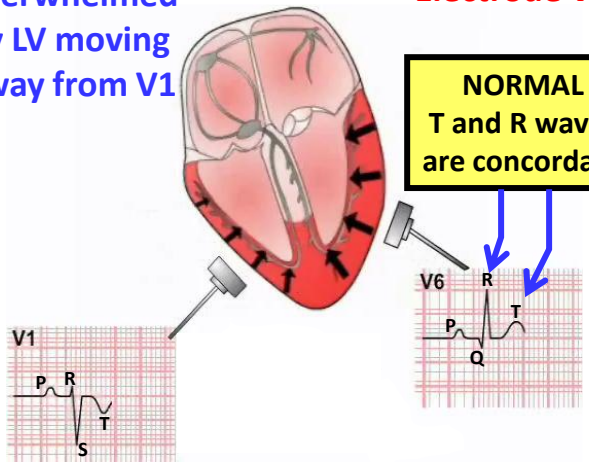


Overwhelmed by LV moving Away from V1

Moving Toward Electrode V6



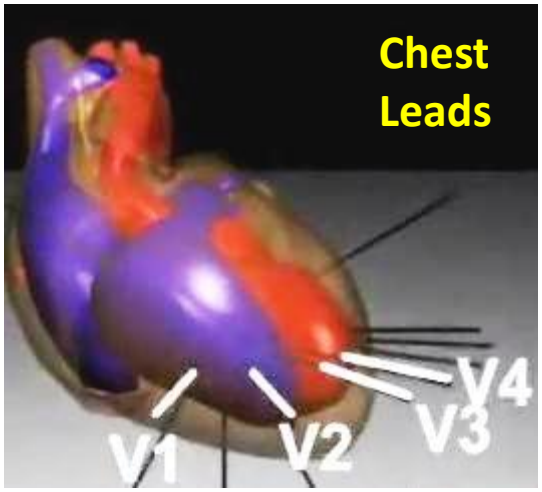
Full Ventricular Depolarization

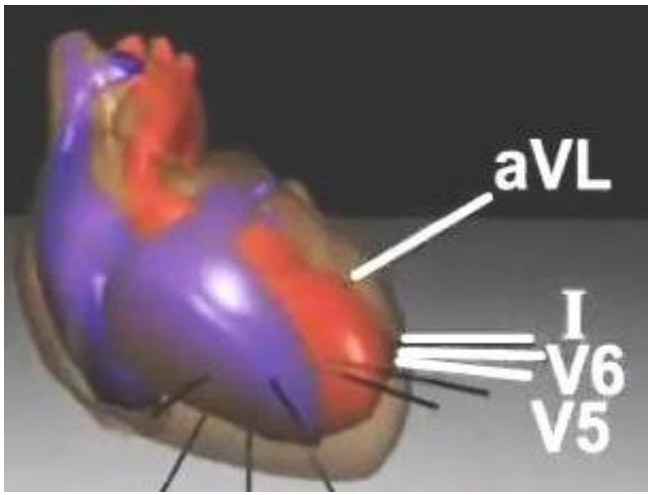


NORMAL T and R waves are concordant

Repolarization away from V6 electrode; Starts at last depolarized sites due to quicker recovery, repolarizes from epicardium to endocardium

Chest and Limb Leads: Sensed Territories

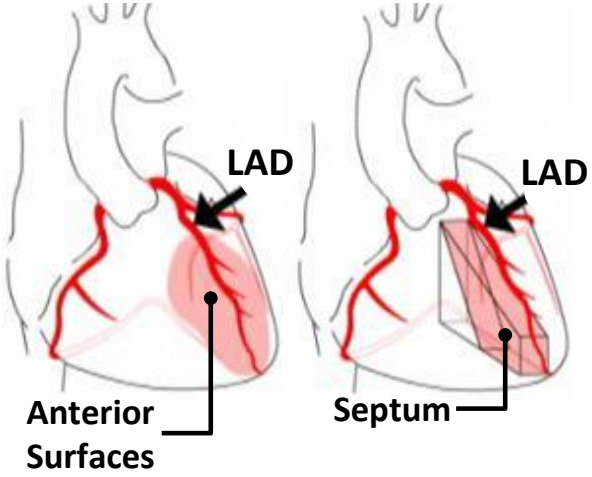


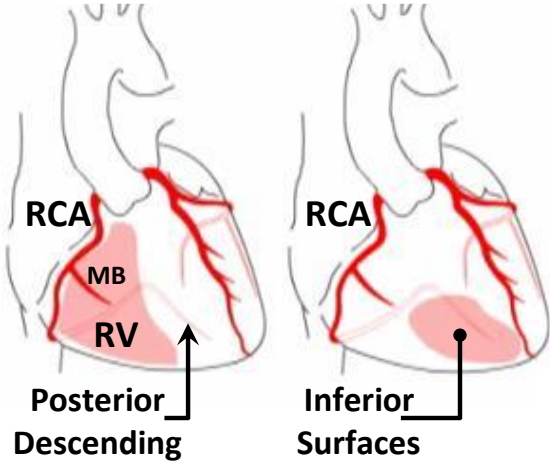


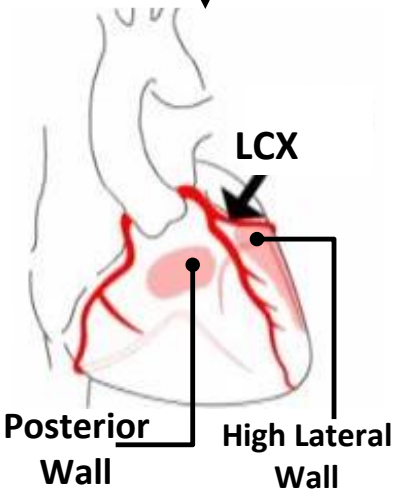
Anterior V1→V4

Inferior III aV_F II

Left Lateral aV_L I V6 V5

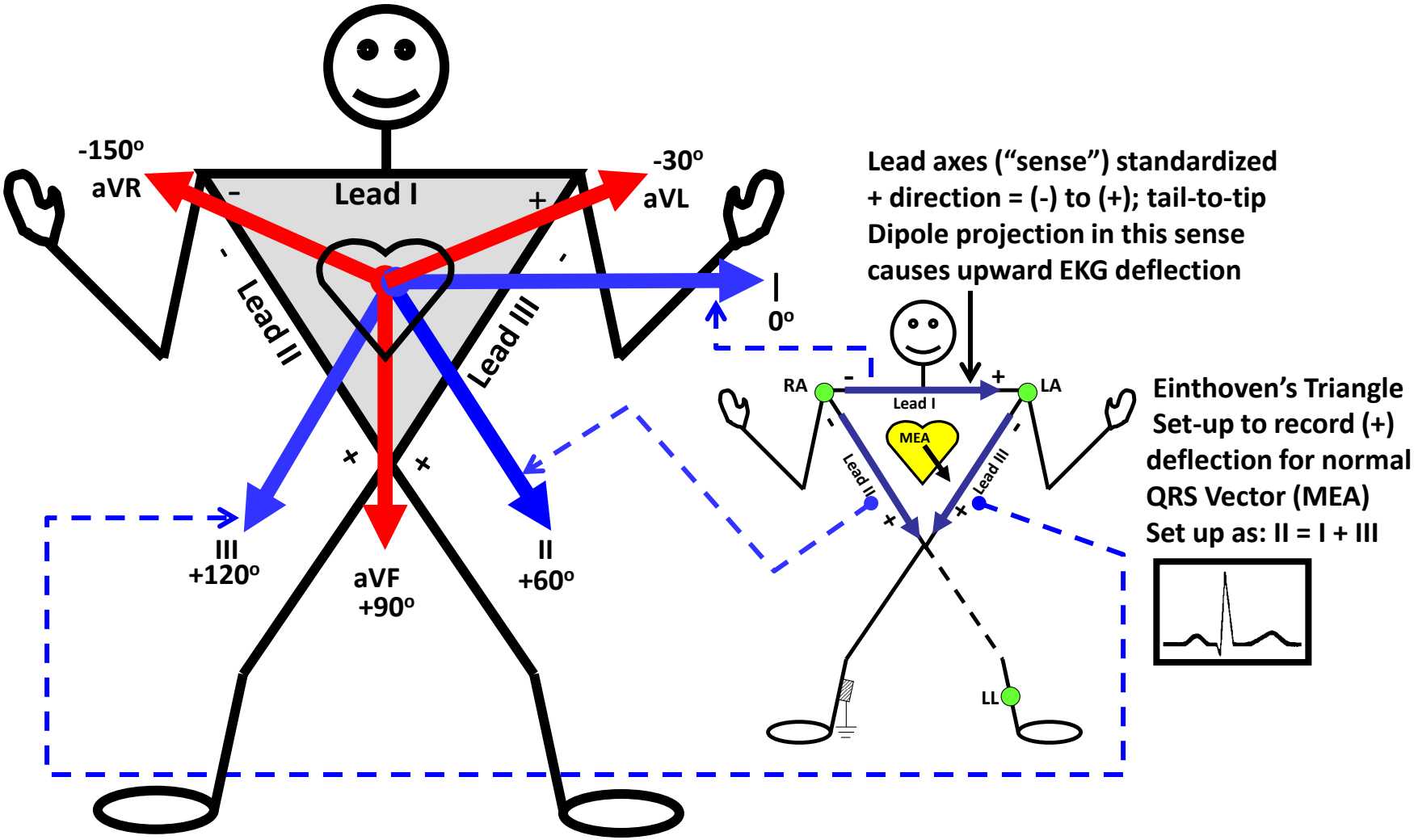




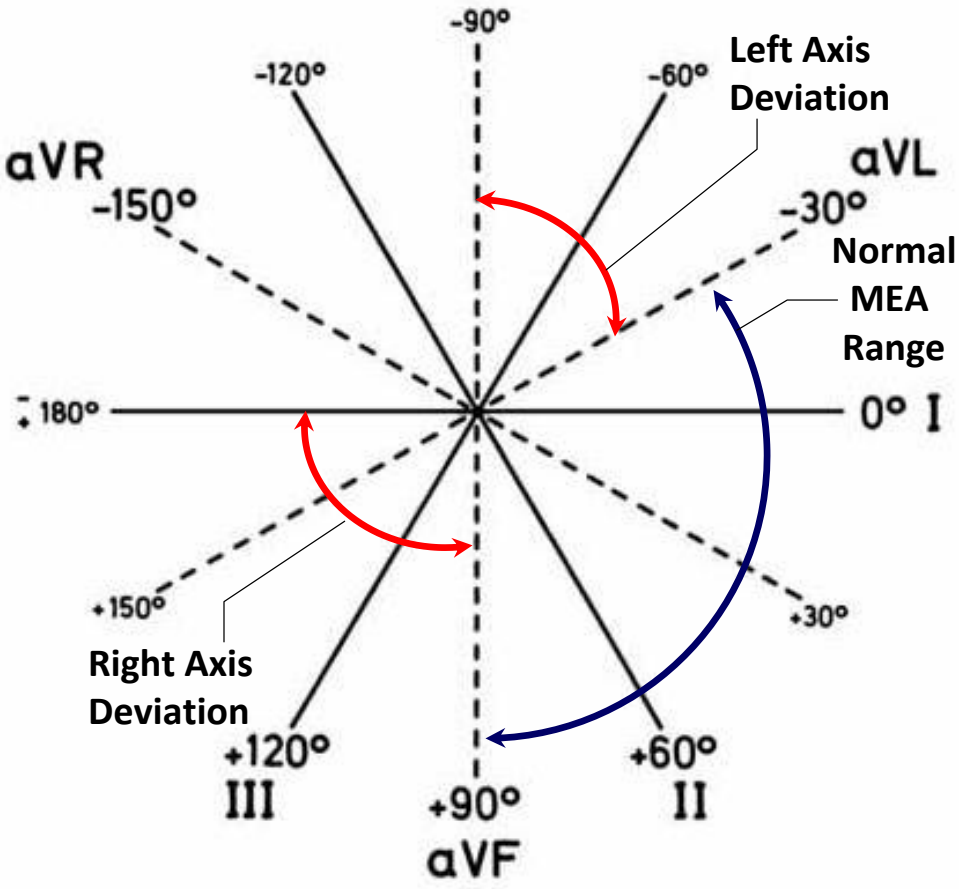


Leads and Axes

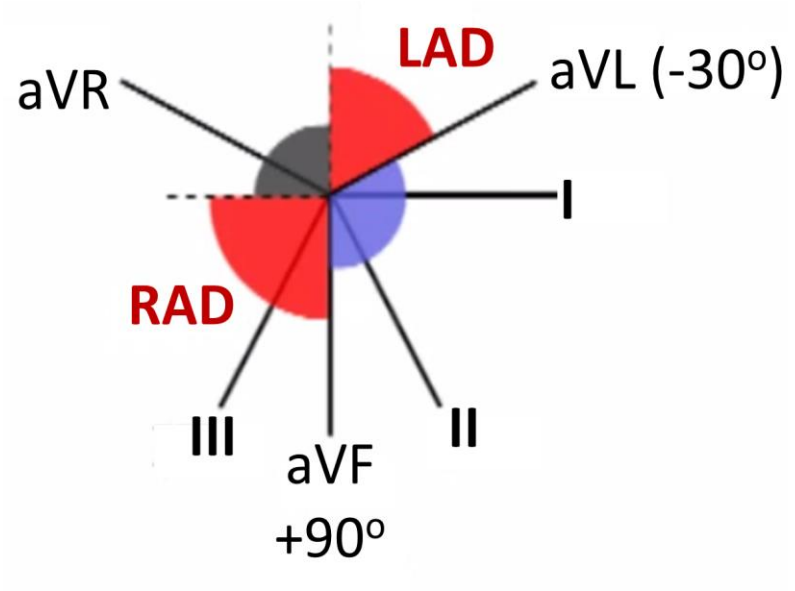
Frontal Plane Leads and Axes: Review



Axis Deviations

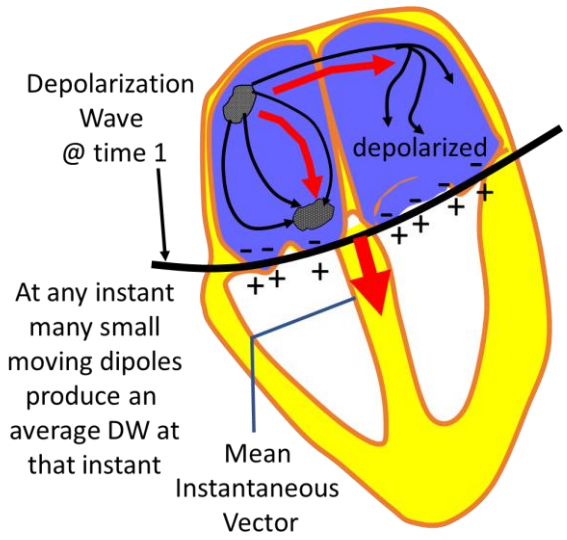


- **RAD**: Right Axis Deviation if MEA beyond +90 to +180
- **LAD**: Left Axis Deviation if MEA beyond -30 to -90

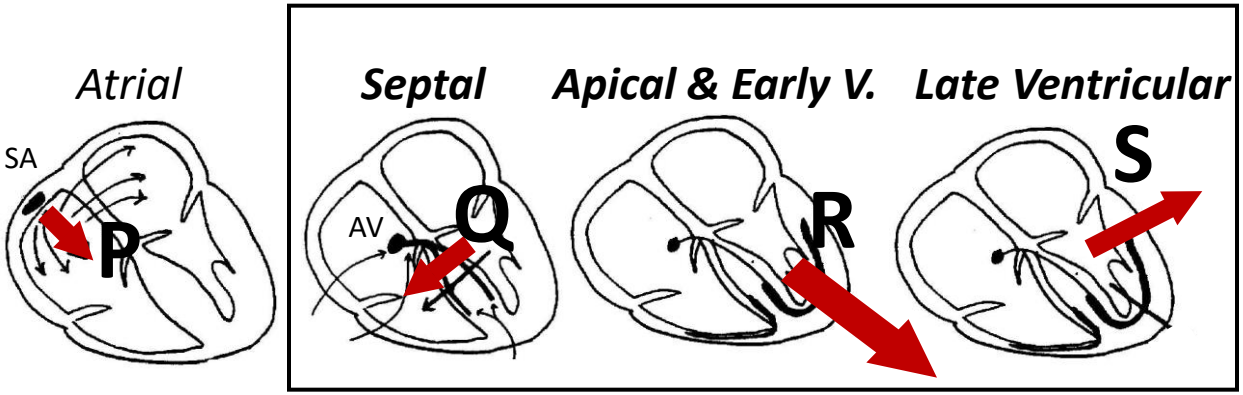


EKG Vector Projection

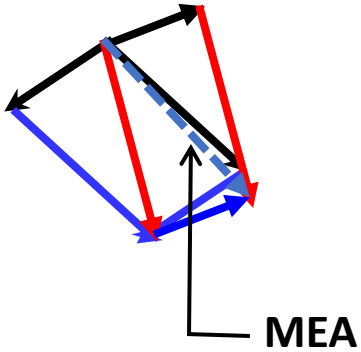
QRS Vector = Mean Electrical Axis (MEA)



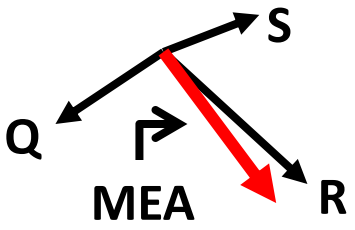
Occur During the QRS Complex



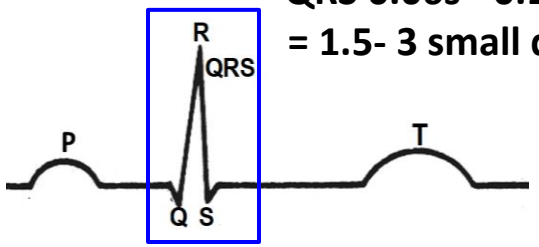
Adding Components



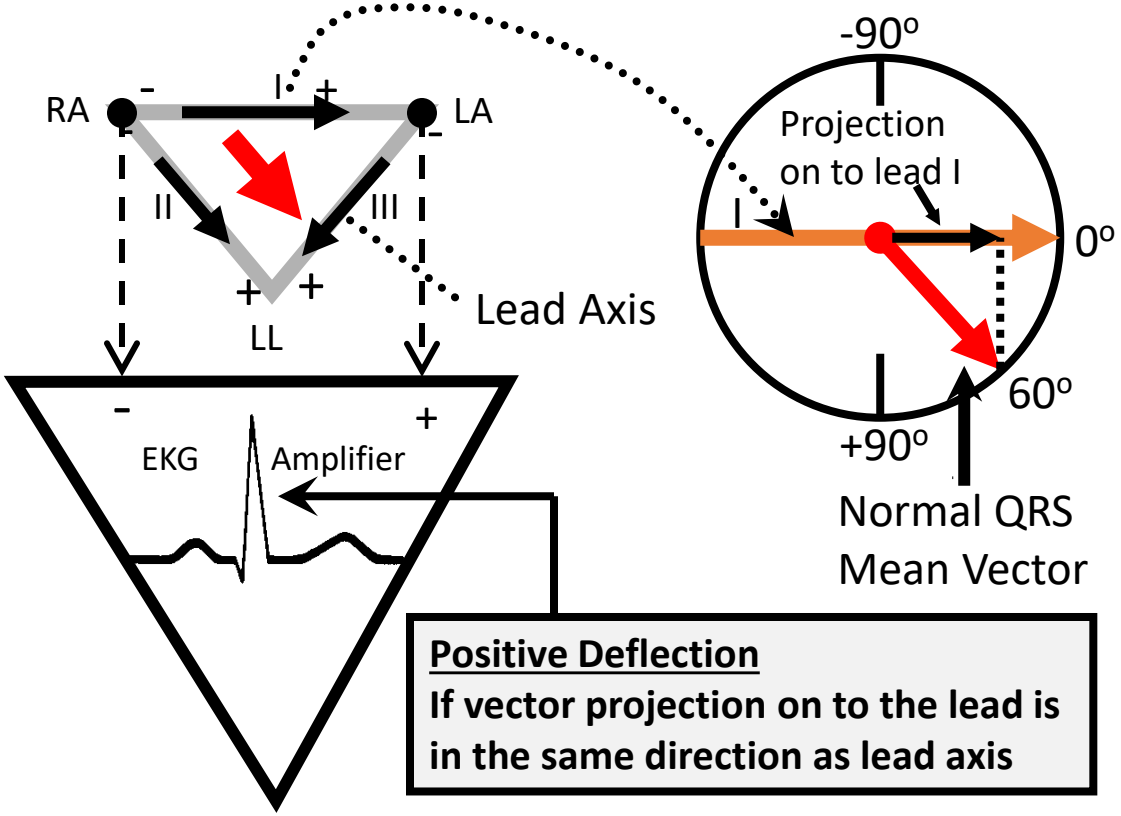
Vector addition determines MEA



QRS 0.06s - 0.12s
= 1.5- 3 small div

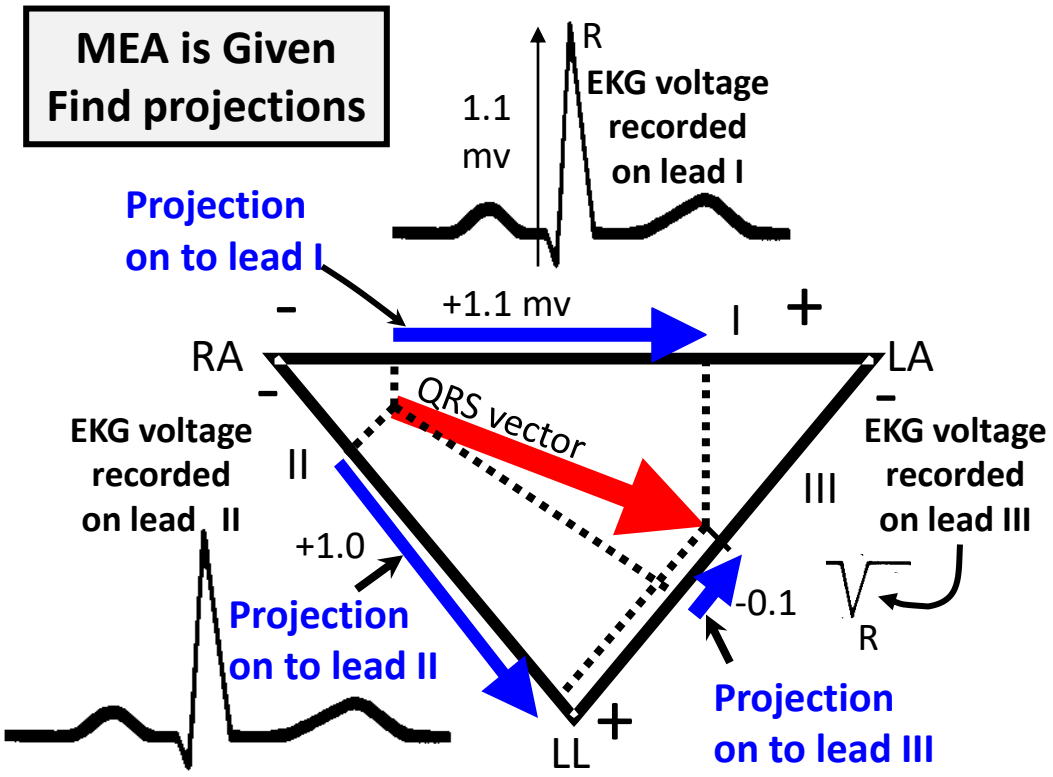


Cardiac Vector Projection

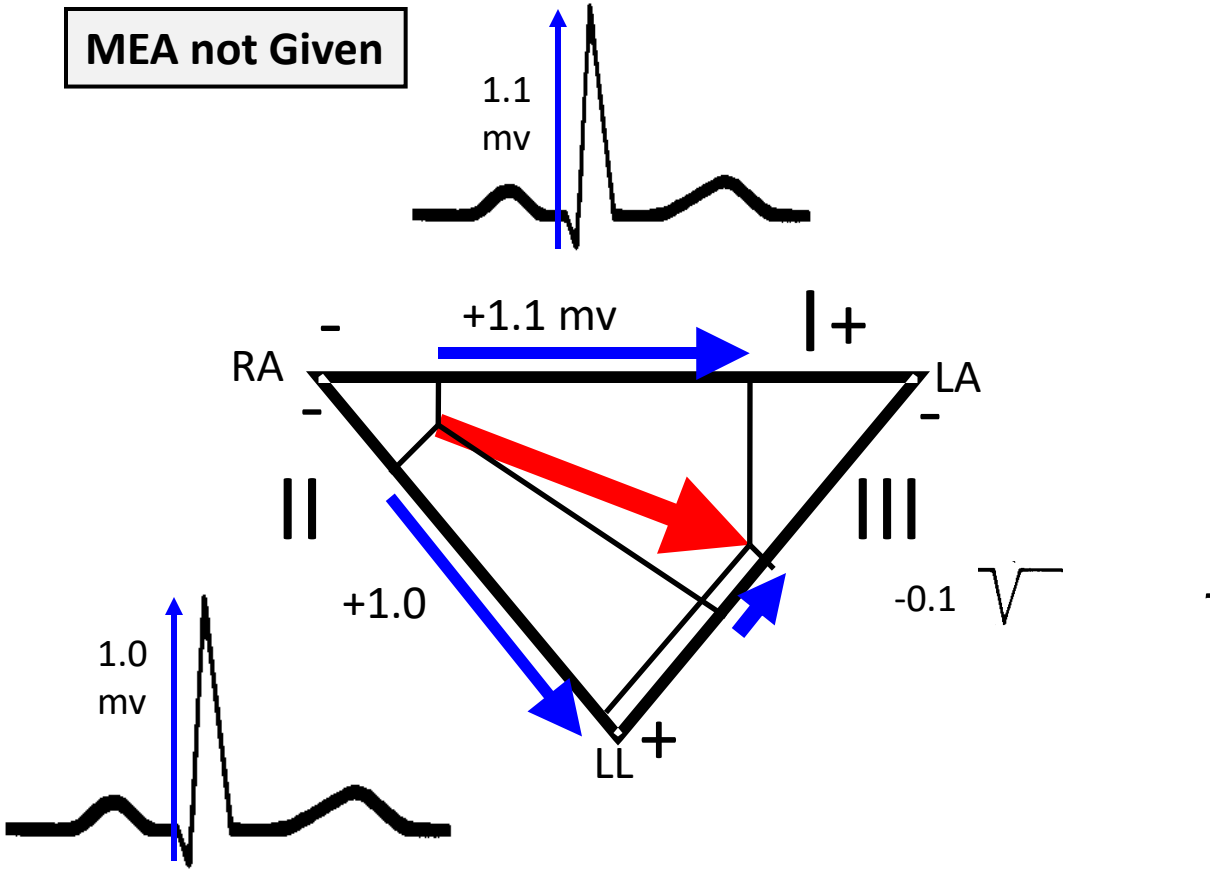


Positive Deflection
If vector projection on to the lead is in the same direction as lead axis

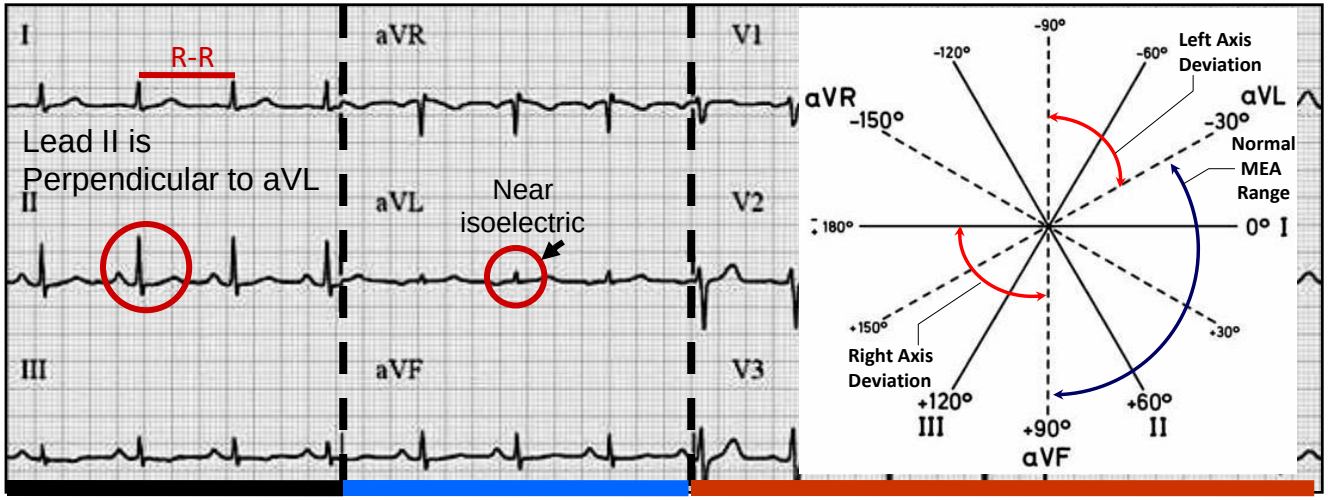
Cardiac Vector Projection Example



Cardiac Vector Projection Example Turned Around



Normal 12-Lead EKG – *Determine MEA*



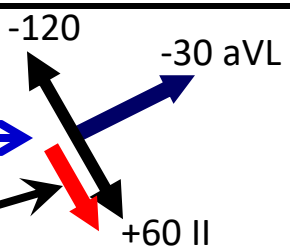
Standard Augmented Precordial

1 mm = 0.1 mv @ 25 mm/sec → 1 mm = 0.04 s or 5 mm = 0.20 s

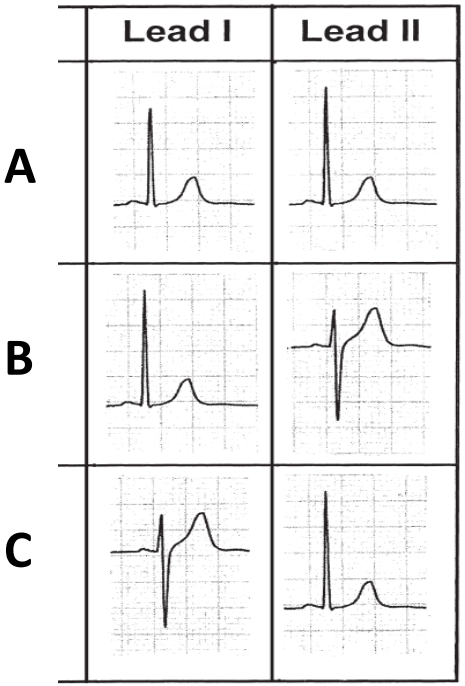
Projection of *unknown* MEA is most perpendicular to aVL

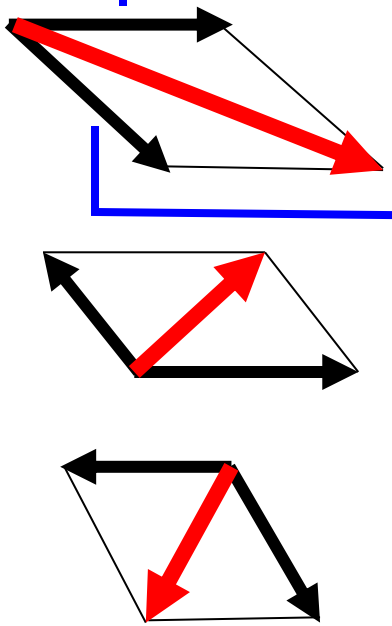
Therefore MEA is ~ 60° or -120°

But, since lead II is + MEA is normal ~60°



For lead I and II patterns shown below, determine which MEA is normal, right axis deviation and left axis deviation

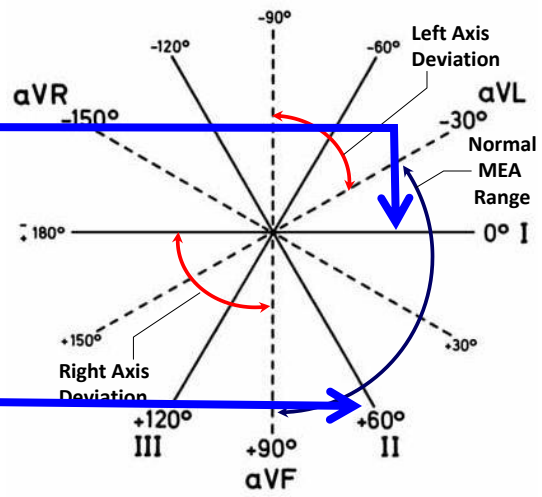




A. NORMAL

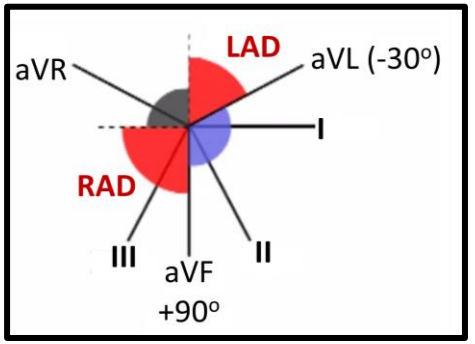
B. LAD

C. RAD



Normal?
RAD?
LAD?

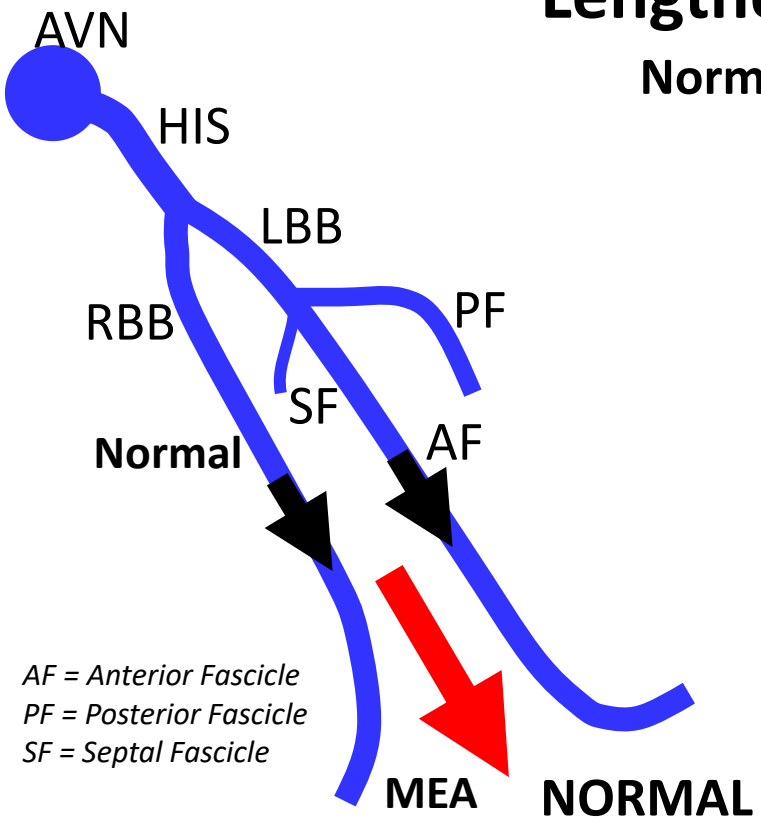
LAD: Left Axis Deviation
RAD: Right Axis Deviation



Conduction Blocks: 1º

Lengthened PR Interval

Normal PR: 0.12 – 0.2 s

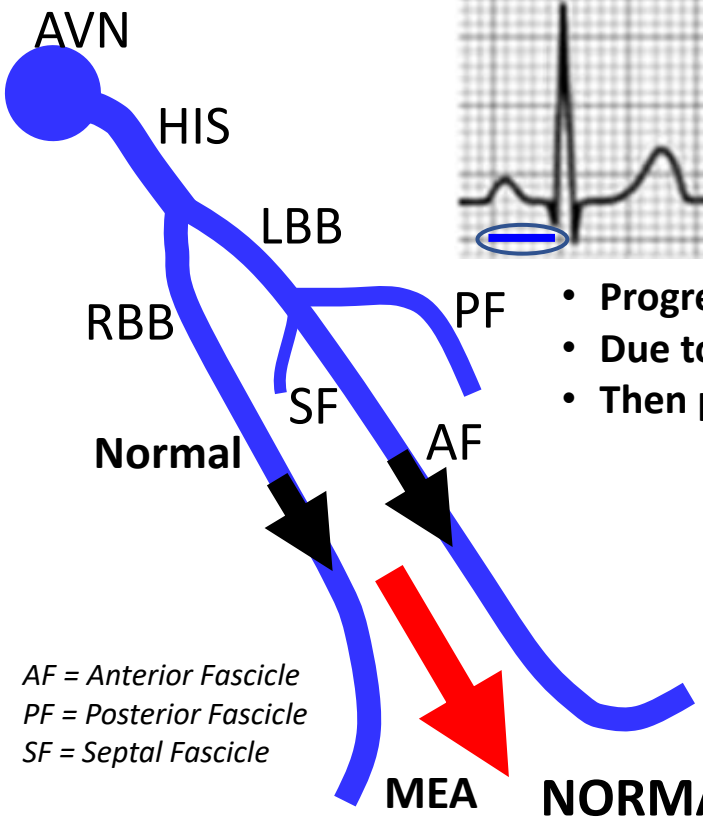


AF = Anterior Fascicle
PF = Posterior Fascicle
SF = Septal Fascicle

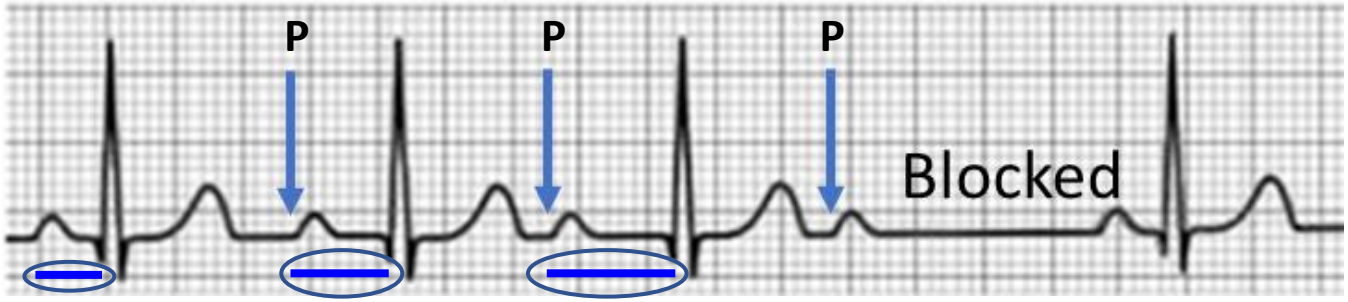
IF PR consistently > 0.2s then 1º block

Often issue is with AVN

Conduction Blocks: 2º



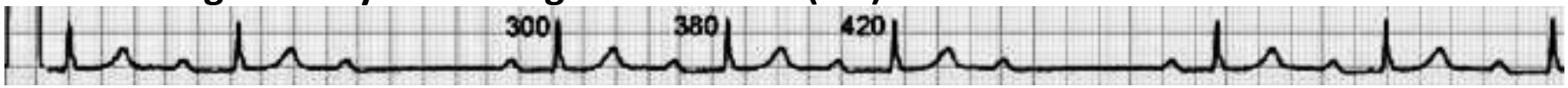
AF = Anterior Fascicle
PF = Posterior Fascicle
SF = Septal Fascicle



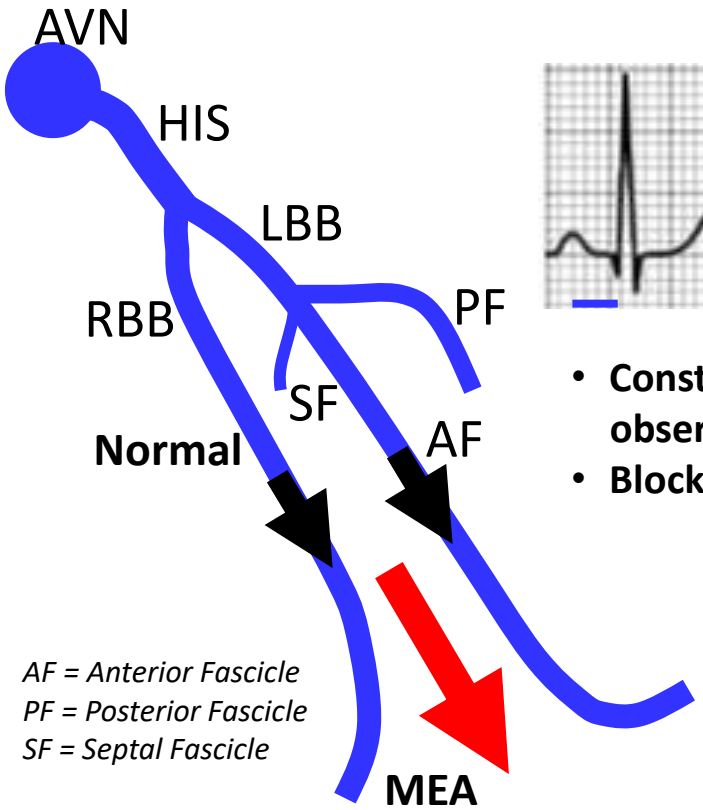
- **Progressively increasing PR interval until a QRS does not occur**
- **Due to AVN refractory**
- **Then pattern repeats**

Mobitz 1 / Wenkebach

Progressively increasing P-R intervals (ms) **Blocked**



Conduction Blocks: 2º

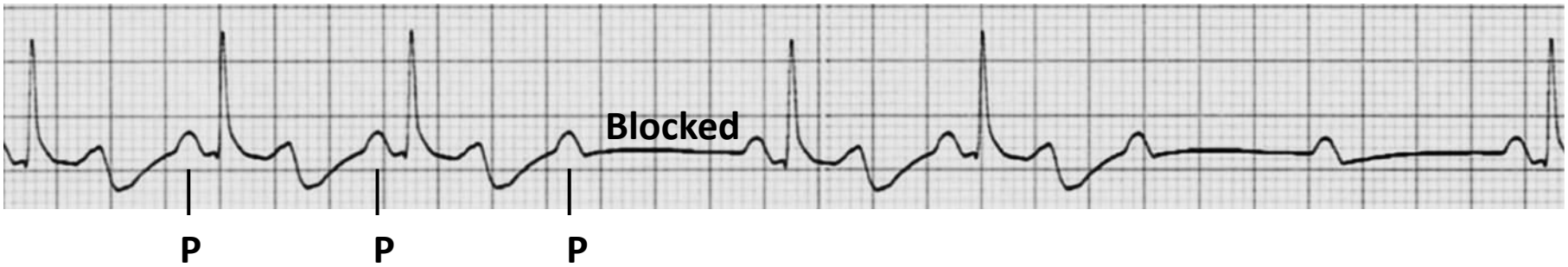


AF = Anterior Fascicle
PF = Posterior Fascicle
SF = Septal Fascicle

- **Constant PR intervals with Intermittently observed drop of QRS following a P-wave**
- **Block almost always with His-Purkinje system**

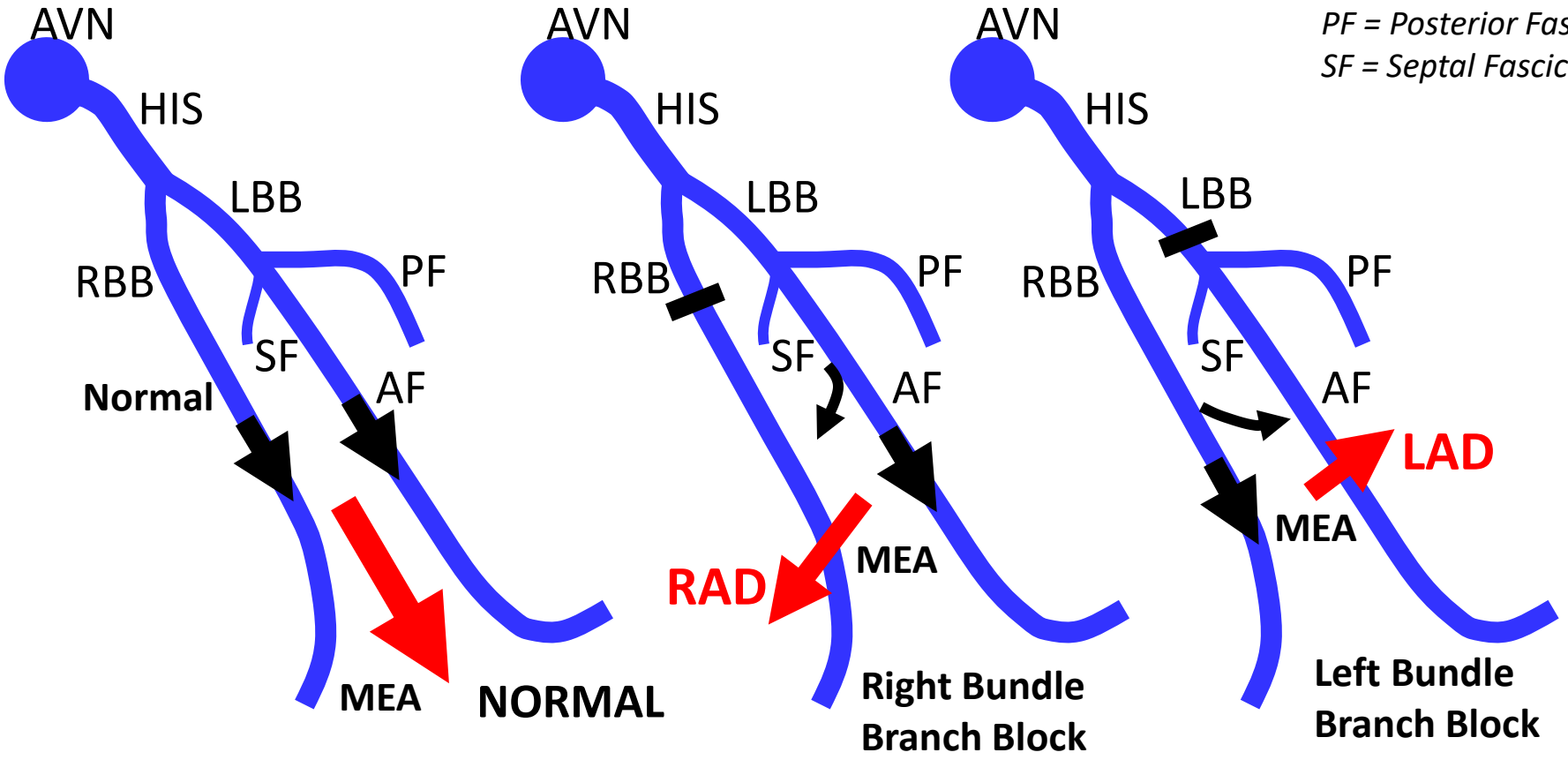
Mobitz 2 / Hay

- **Regular atrial rhythm after QRS**
- **Irregular ventricular rhythm**



Conduction Blocks as Source of Axis Deviation

AF = Anterior Fascicle
PF = Posterior Fascicle
SF = Septal Fascicle

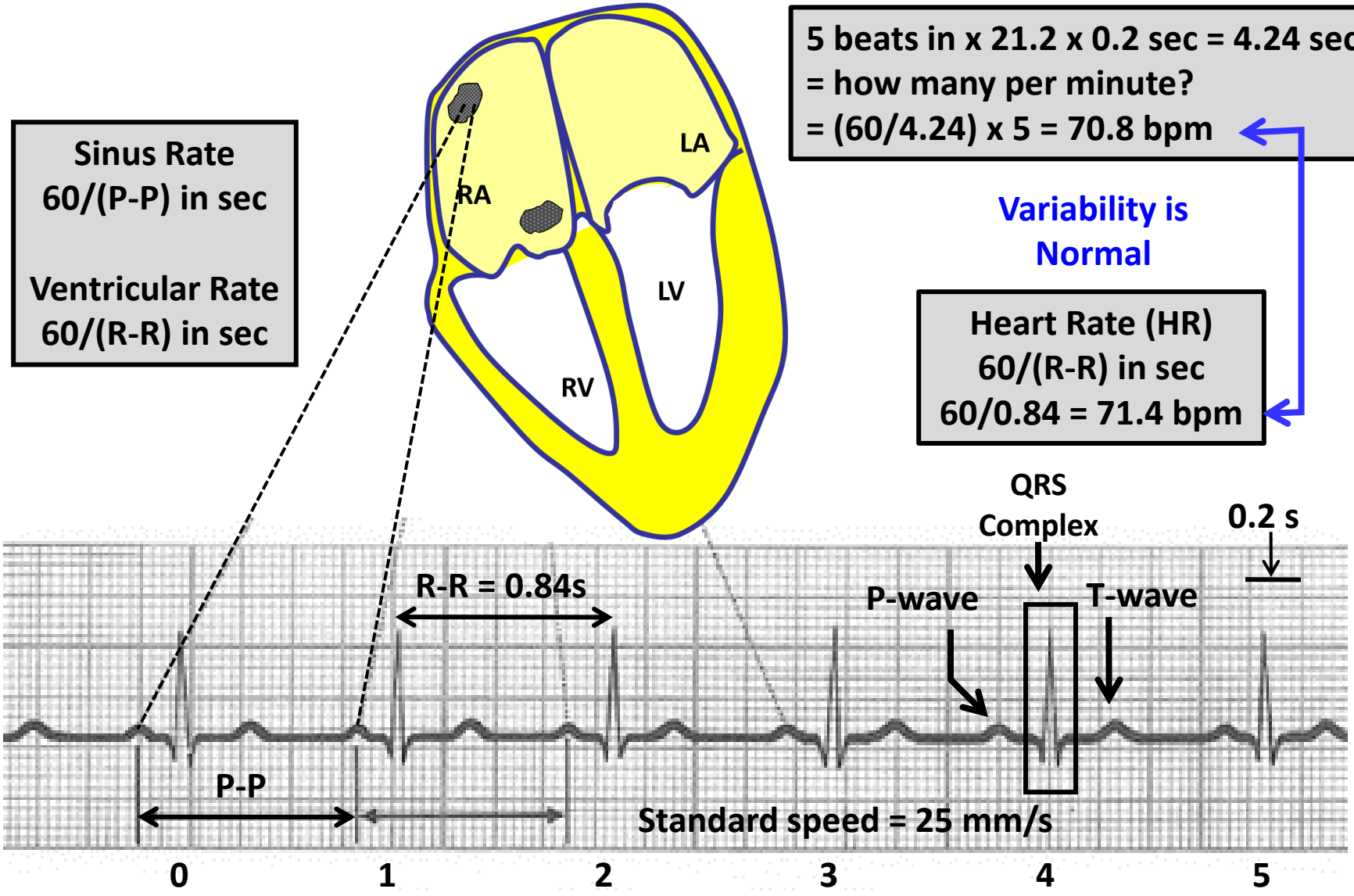


MEA TIDBITS

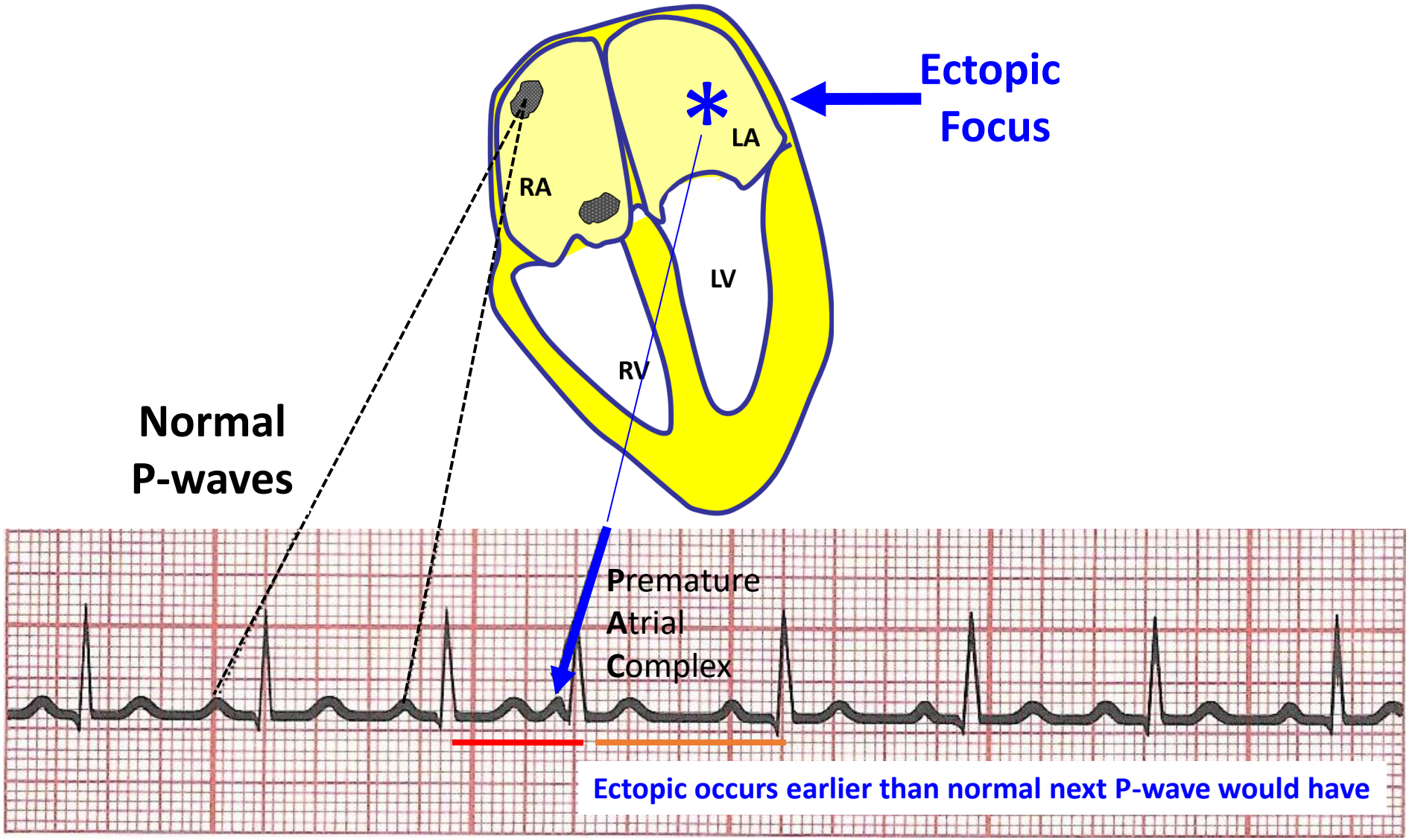
- **MEA shift in the direction of a shift in long-axis of the heart**
- **MEA shifts toward an area of hypertrophied myocardium**
- **MEA shifts away from an area of infarcted myocardium**
- **MEA shifts toward the bundle branch block side**

EKG Patterns
Normal and Not-So-Normal
(as time permits)

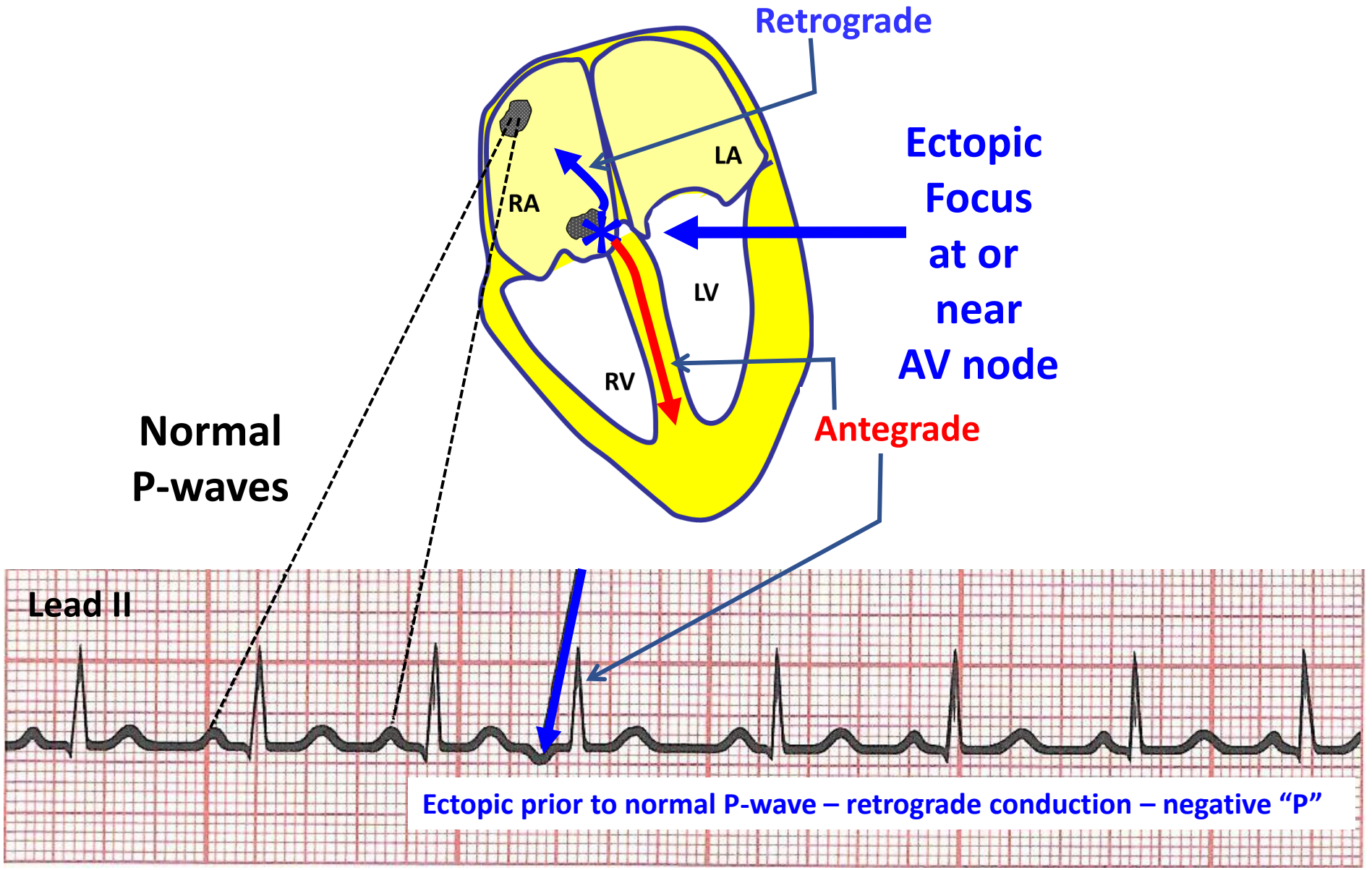
Normal


5 beats in x 21.2 x 0.2 sec = 4.24 sec
= how many per minute?
= (60/4.24) x 5 = 70.8 bpm
Variability is Normal
Sinus Rate
60/(P-P) in sec
Ventricular Rate
60/(R-R) in sec
Heart Rate (HR)
60/(R-R) in sec
60/0.84 = 71.4 bpm
LA
RA
LV
RV
QRS Complex
0.2 s
R-R = 0.84s
P-wave
T-wave
P-P
Standard speed = 25 mm/s
0
1
2
3
4
5

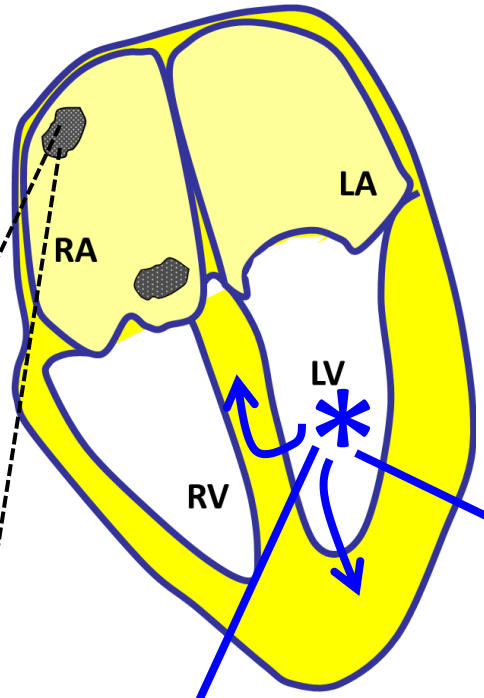
Atrial Ectopic Impulse – Early



Ectopic Impulse – Negative P-Wave



Ectopic Impulse – Ventricular

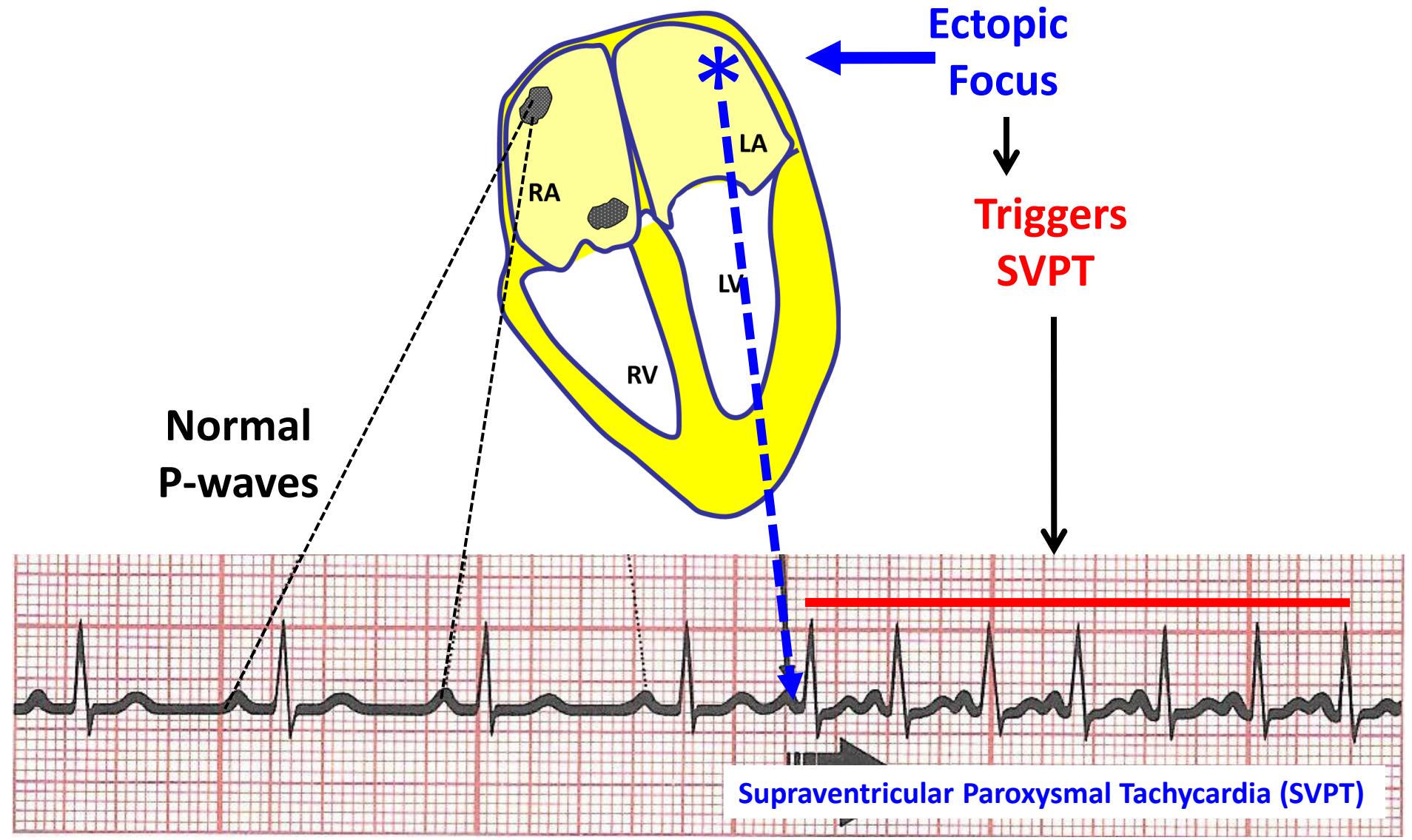


Ectopic Focus in ventricle muscle or conduction pathway

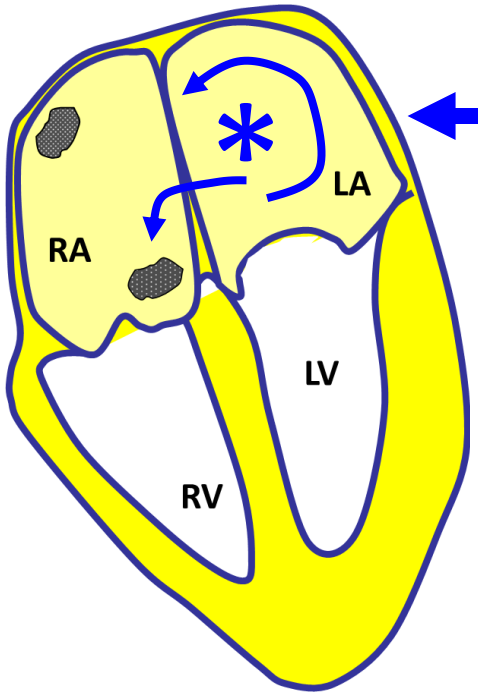
Normal P-waves

Ectopic prior to normal P-wave – retrograde and antegrade conduction

Supraventricular Paroxysmal Tachycardia



Flutter Waves



Ectopic Focus With Reentry and Re-excitation

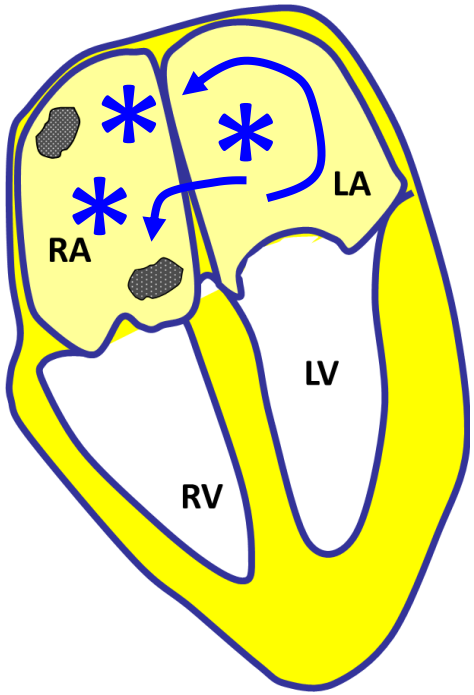
"Flutter Waves"

0.6 s

HR = 60/0.6 =100

Atrial depolarizations not passing through AV

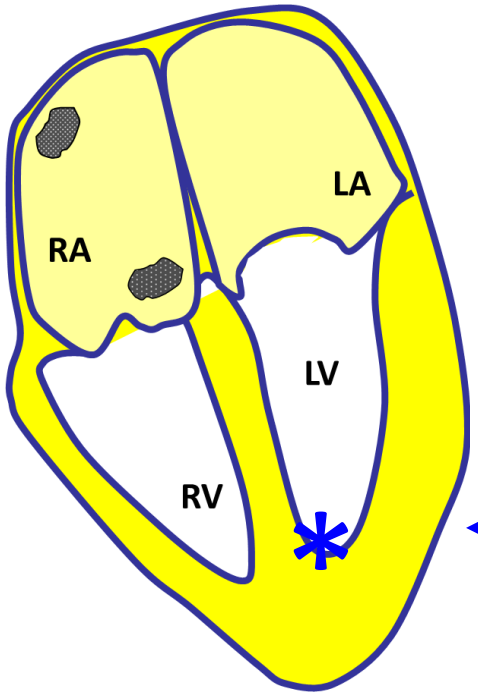
Atrial Fibrillation



MULTIPLE Ectopic Foci causing uncoordinated impulse transmission through AVN

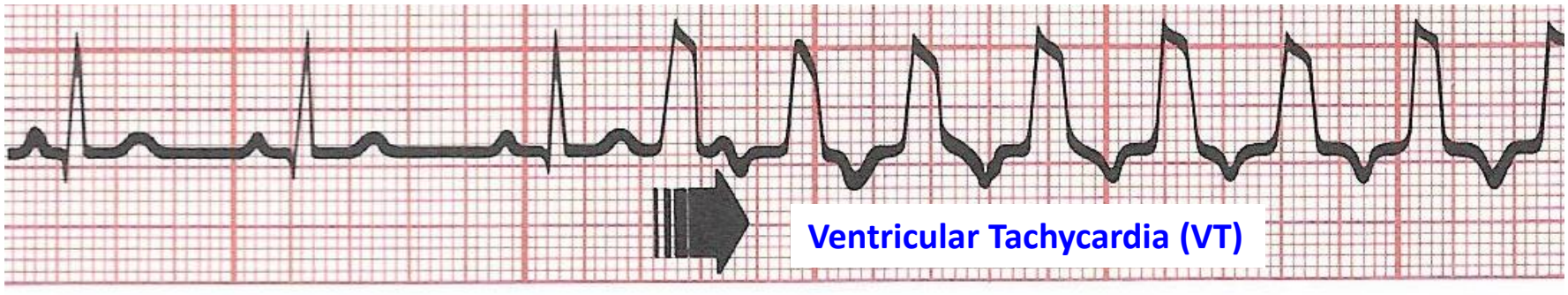
Atrial Fibrillation (aFib) → Rhythm is <u>irregularly irregular</u>

Ventricular Tachycardia

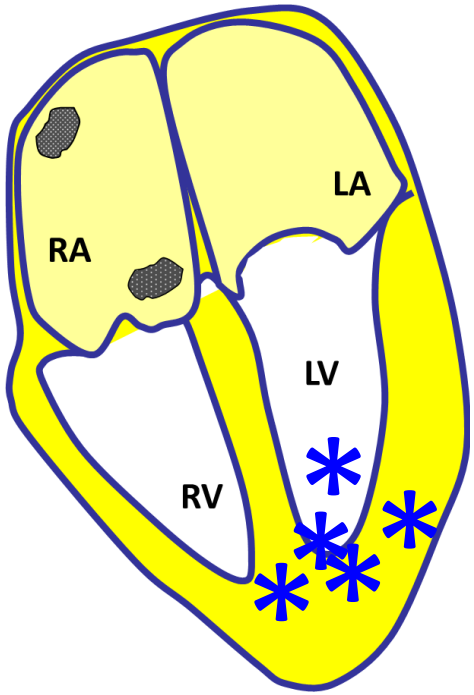


Ectopic Focus Ventricle Triggers VT

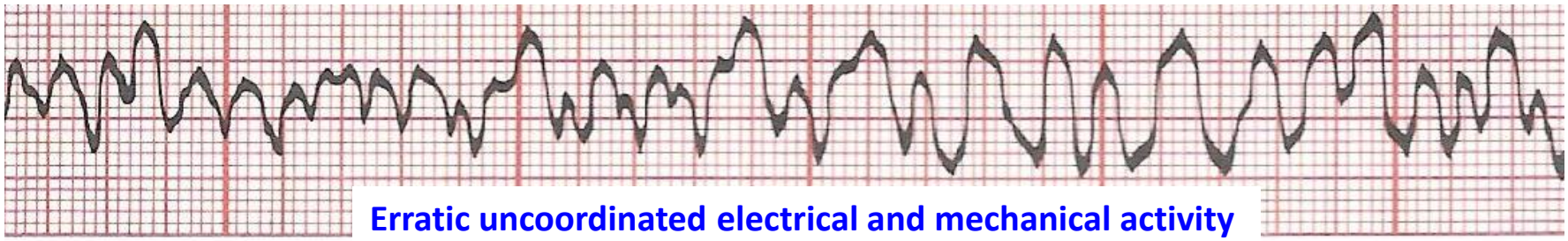
HR ~ 60/0.4 = 150 bpm



Ventricular Fibrillation



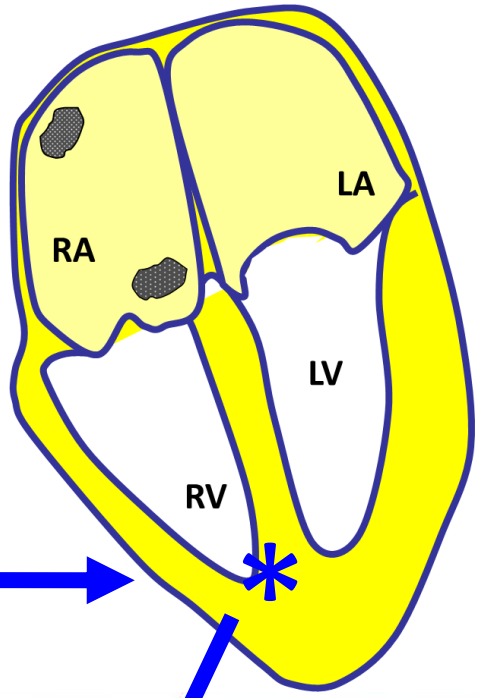
MULTIPLE Ectopic Foci



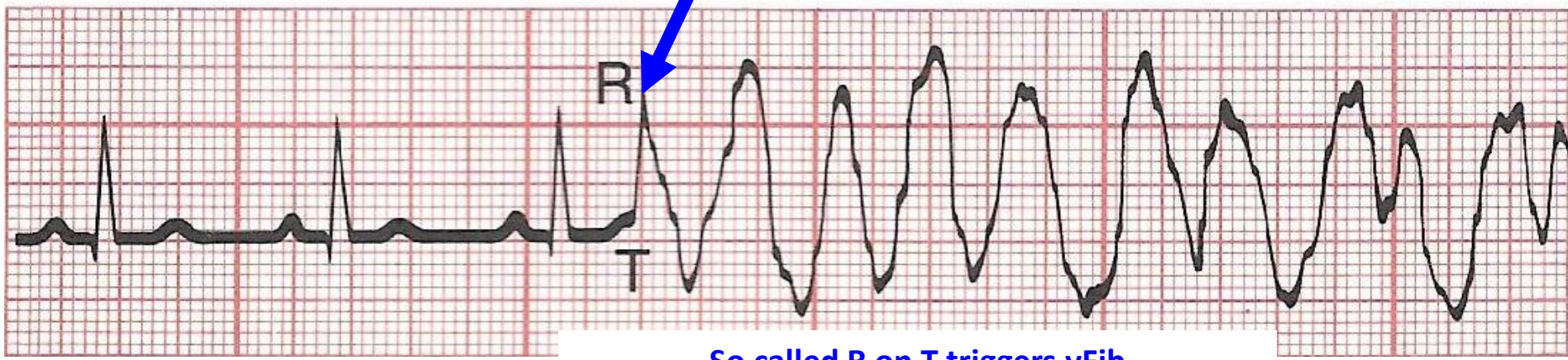
Erratic uncoordinated electrical and mechanical activity

R on T: Ventricular Fibrillation

Ectopic impulse occurs during a vulnerable interval as ventricle is repolarizing (T-Wave upstroke)



Similar Effect with Commotio Cordis



So called R on T triggers vFib

End Lecture 24