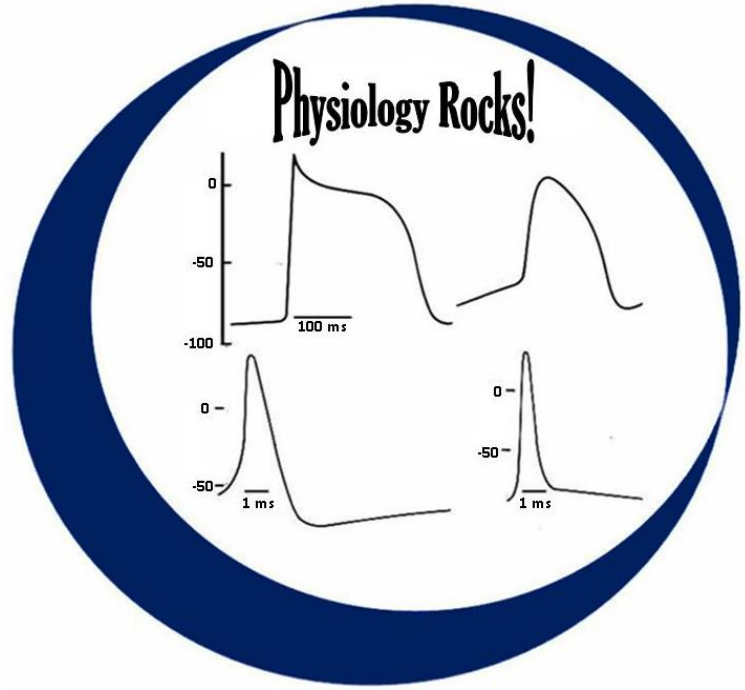
Lecture 3
Introduction to Electrocardiography



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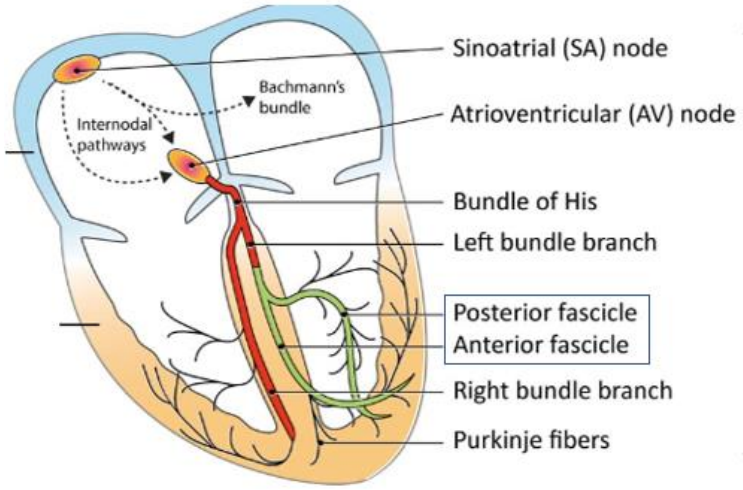
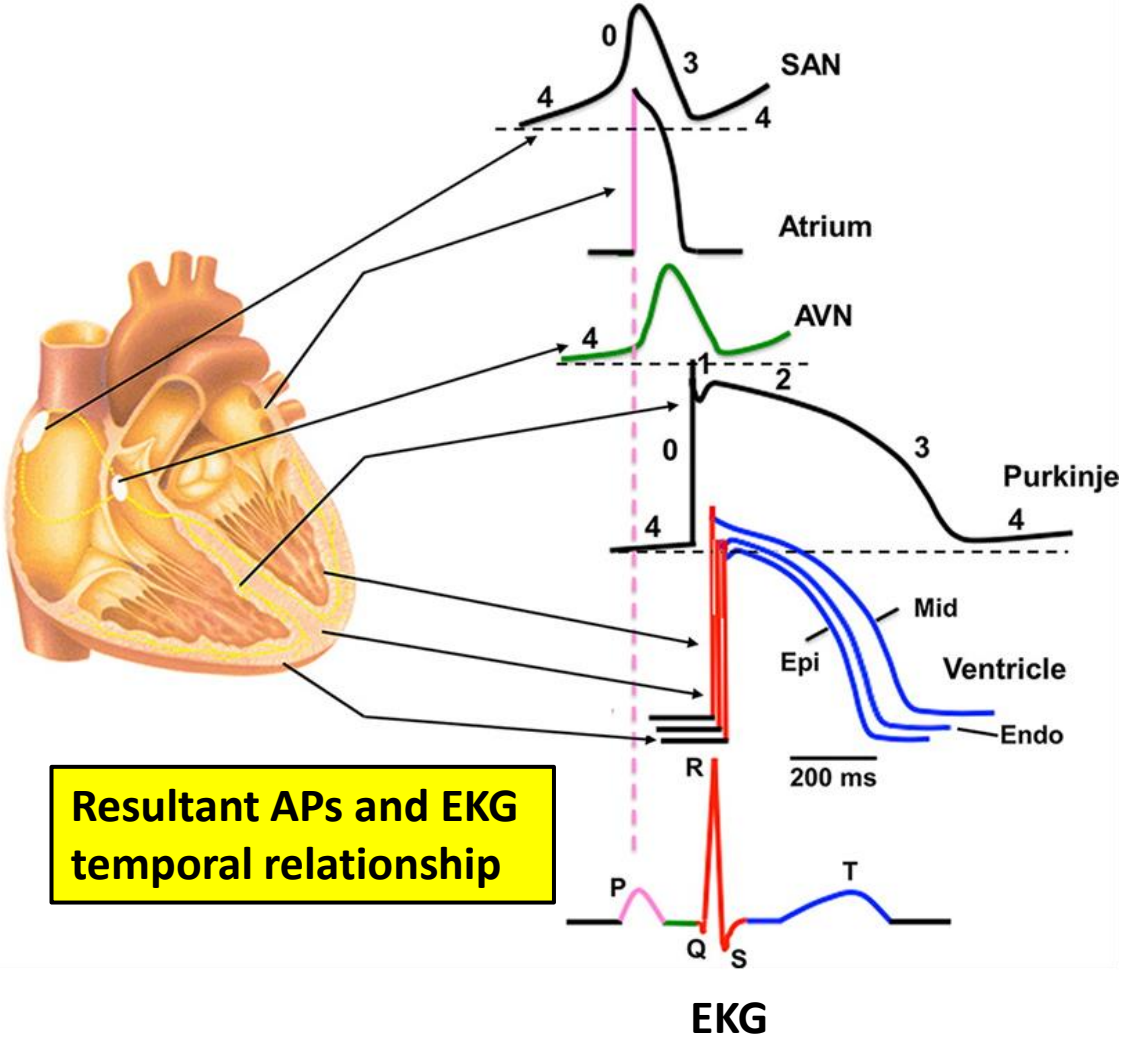
Topics

- Action potential – EKG relationship overview
- Moving electrical dipoles as a source of EKG signals
- EKG waves and intervals in relation to action potentials
- Measuring the EKG – leads and axes introduction
- EKG waves in relation to myocardial territories
- Conduction blocks
- Mean electrical axis (MEA) and axis deviations
- Vector projections to determine MEA
- EKG basic patterns
  - Normal
  - Ectopic impulses – Atrial and Ventricular
  - Tachycardias
  - Flutter wave
  - Atrial fibrillation
  - Ventricular fibrillation

Action potential conduction as EKG source

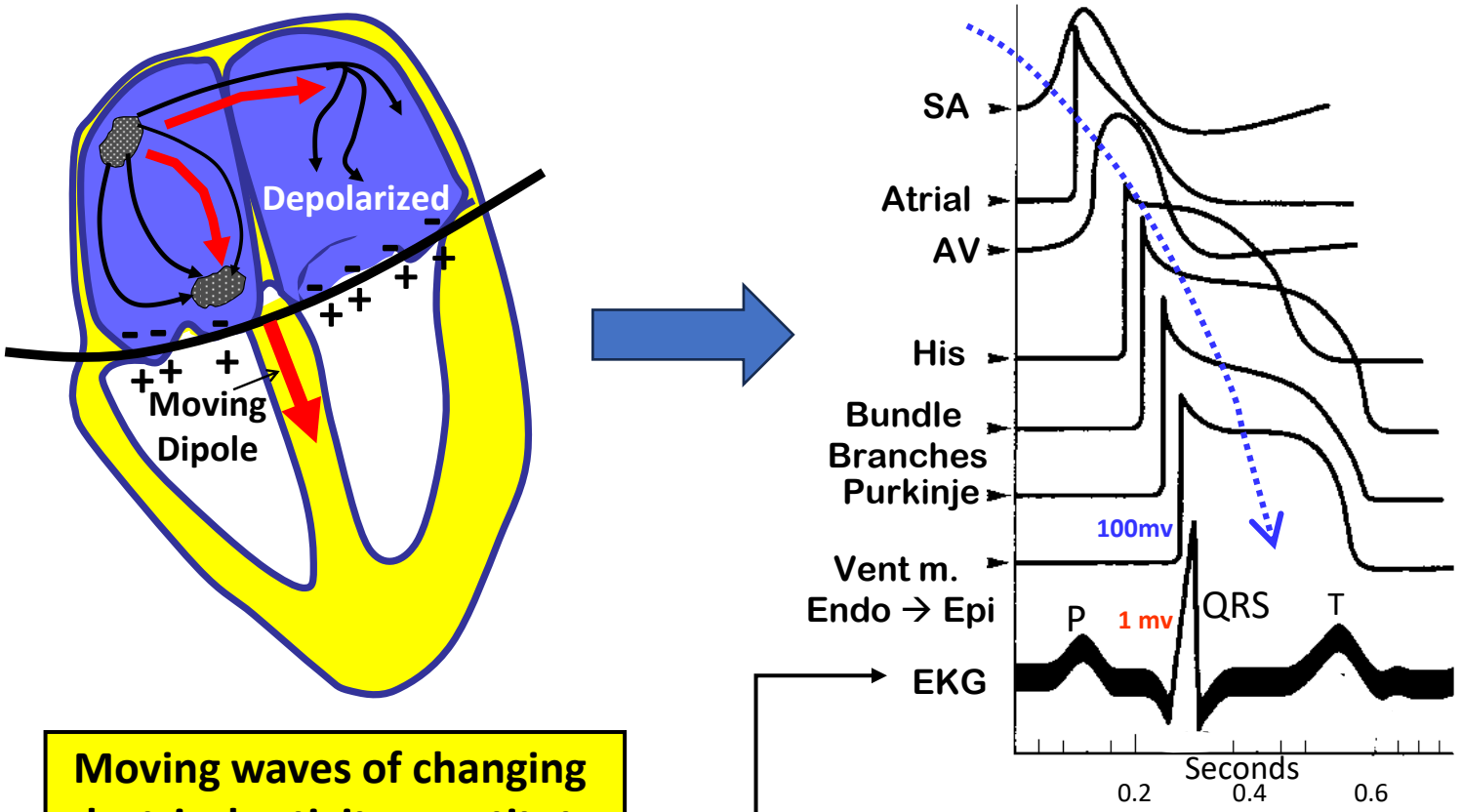
Electrical Conduction Quick Review





Resultant APs and EKG temporal relationship

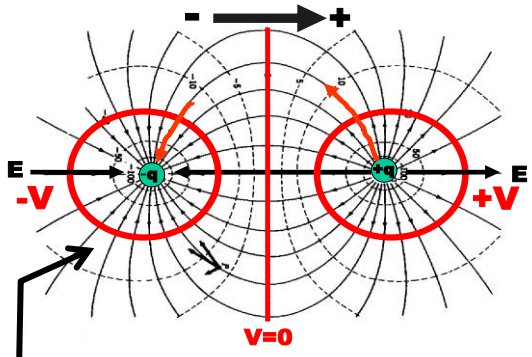
Moving waves of Changing Electrical Activity

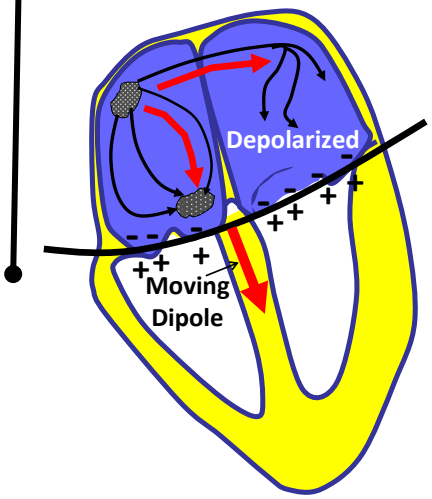


Moving waves of changing electrical activity constitute a moving dipole resulting in the measured EKG

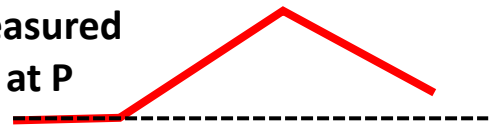
Moving Dipole → Voltage Change at a Distance

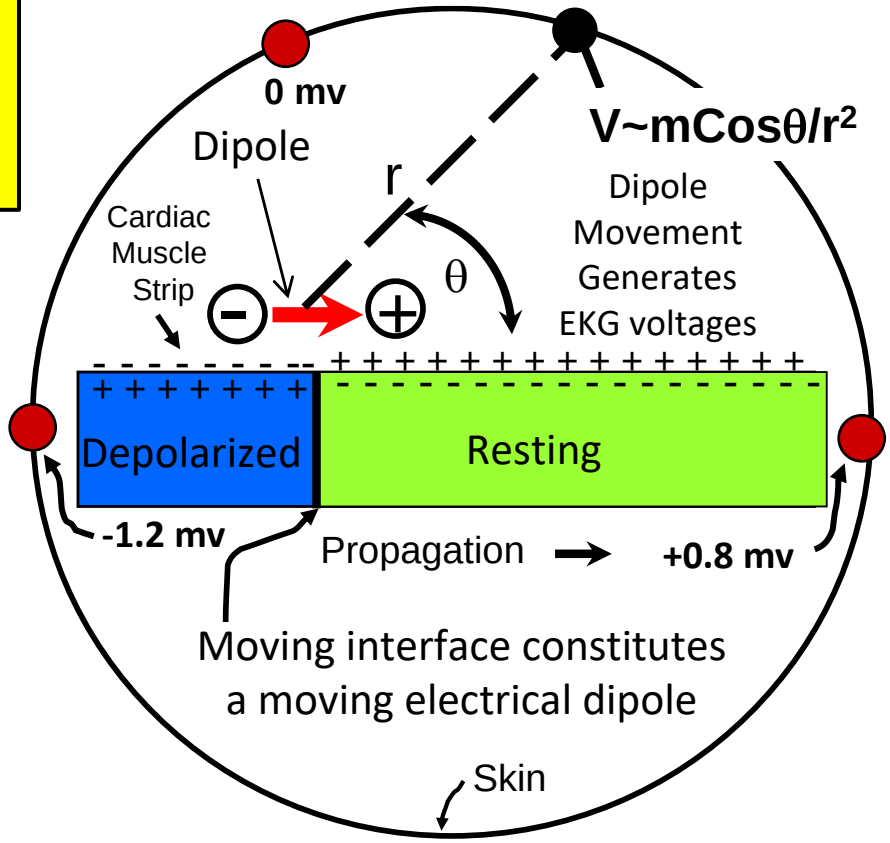
- **Dipole: Equal but opposite separated charge**
- **Moving wave of cardiac depolarization viewed as a moving dipole**
- **As long as its moving it generates a voltage**
- **Sensed (measured) voltage is the EKG (ECG)**



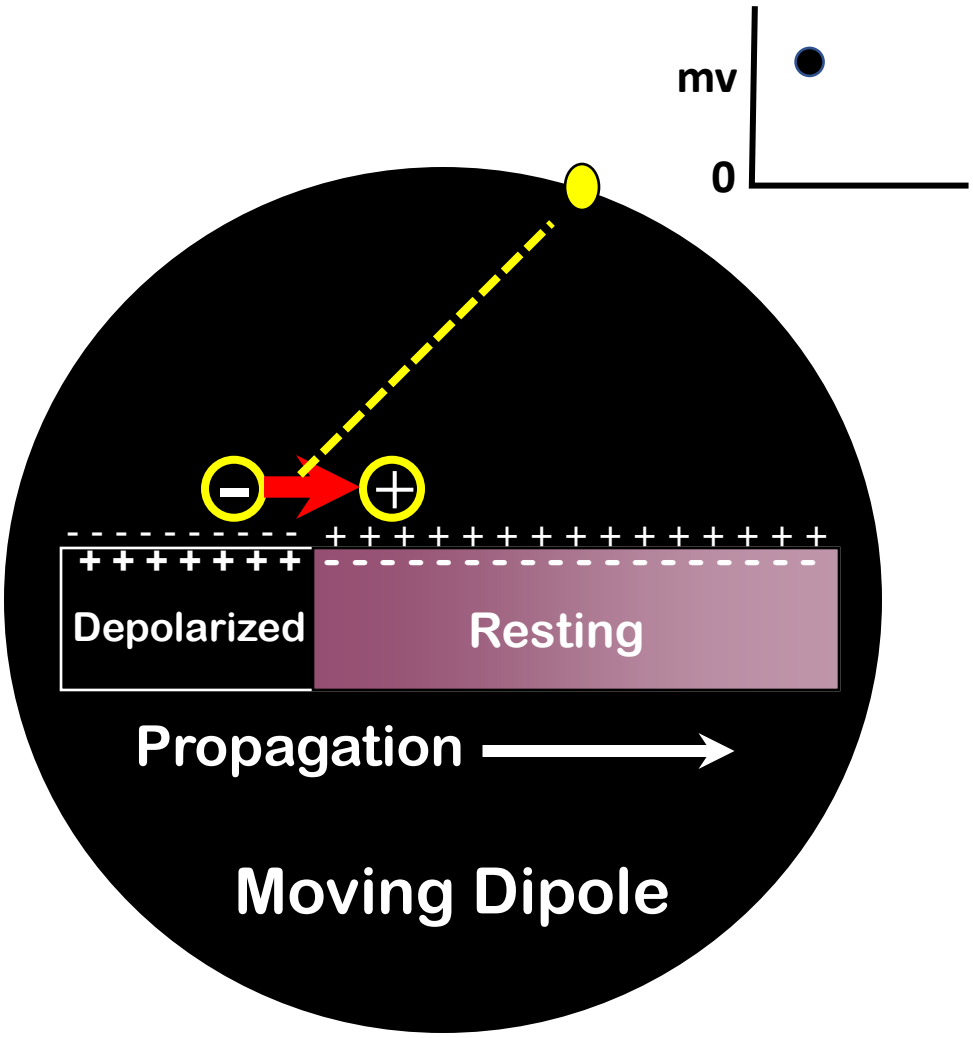


Voltage changes measured at P

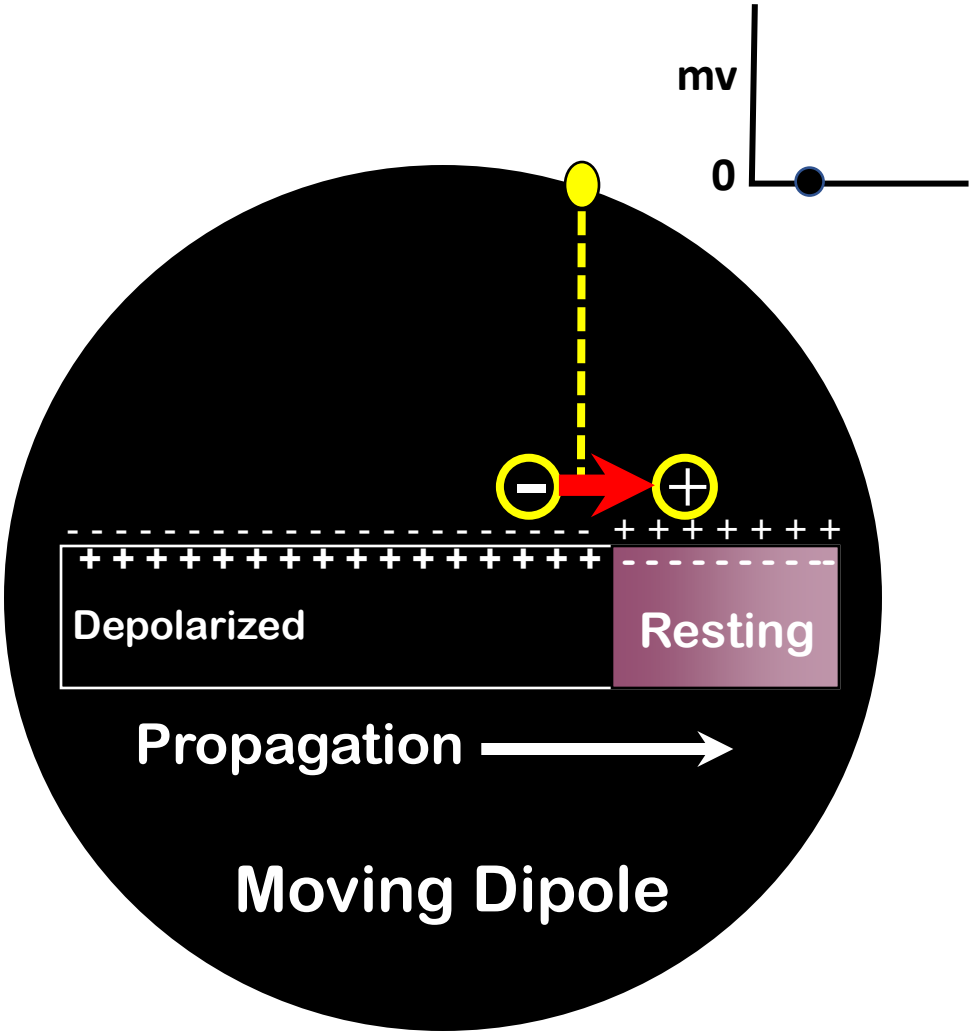




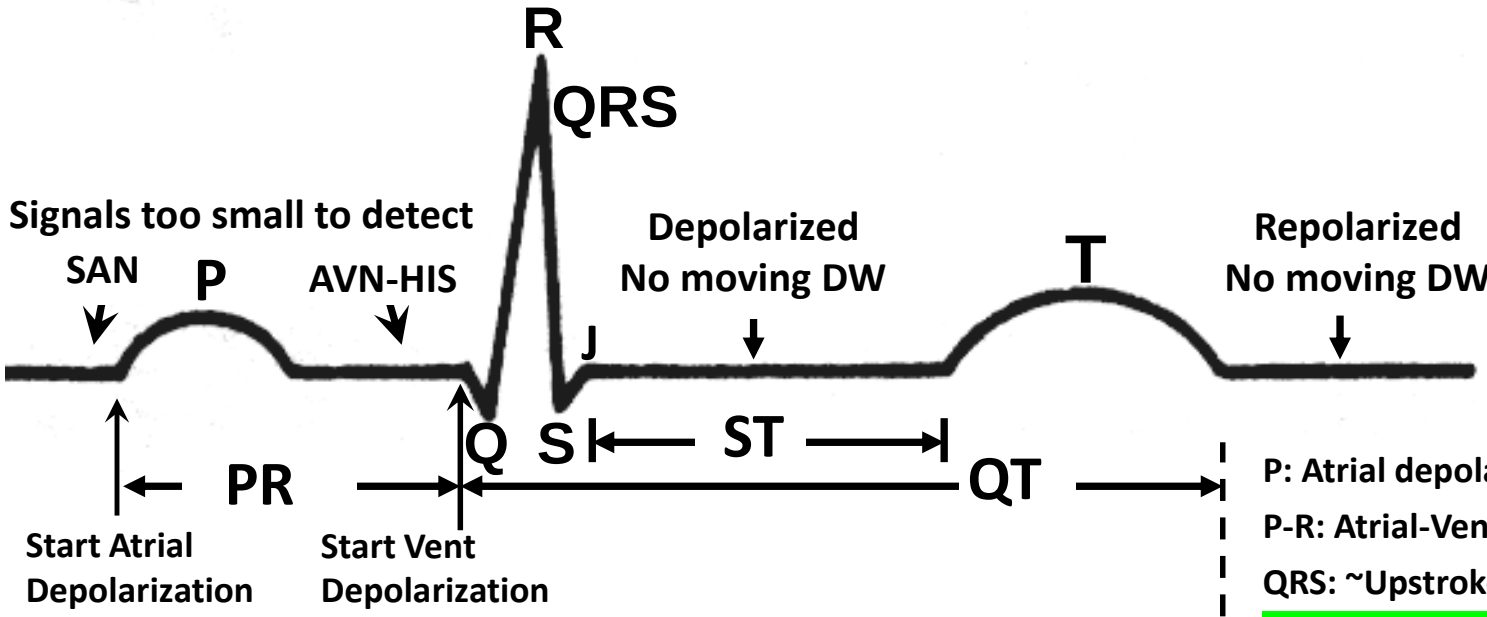
Moving Dipole → Voltage Change at a Distance

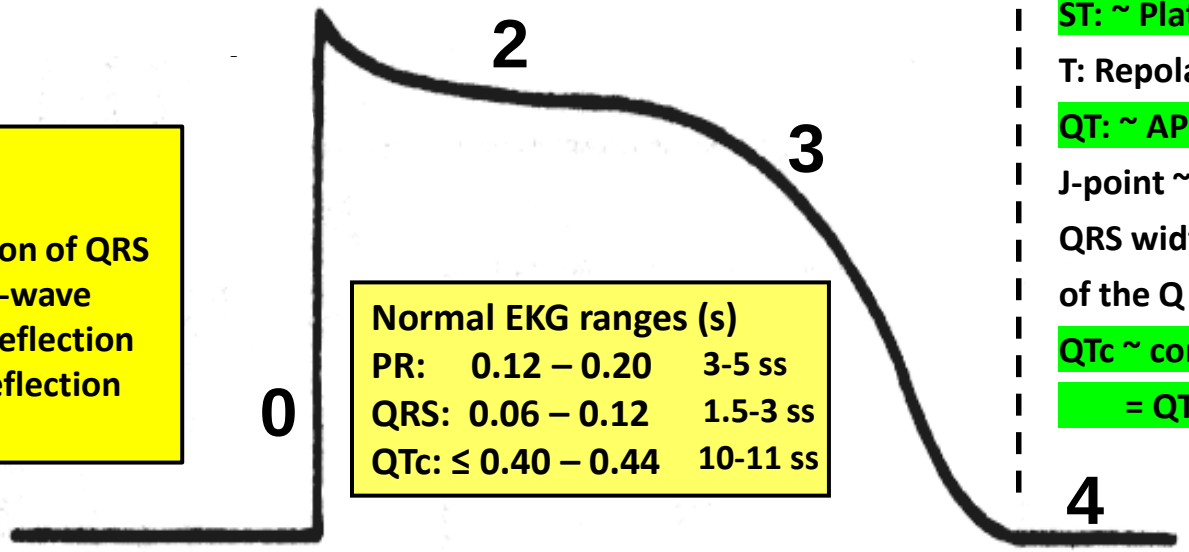


Moving Dipole → Voltage Change at a Distance



EKG Components and Relationship to AP





P: Atrial depolarization

P-R: Atrial-Ventricular

QRS: ~Upstroke (Φ_0)

ST: ~ Plateau (Φ_2)

T: Repolarization (Φ_3)

QT: ~ AP Duration

J-point ~ start of ST

QRS width is from start of the Q to the J-point

QTc ~ corrected for HR = QT/sqrt(R-R)

EKG waves labeled at "turning points"

Q-wave → if 1st deflection of QRS complex is negative = Q-wave

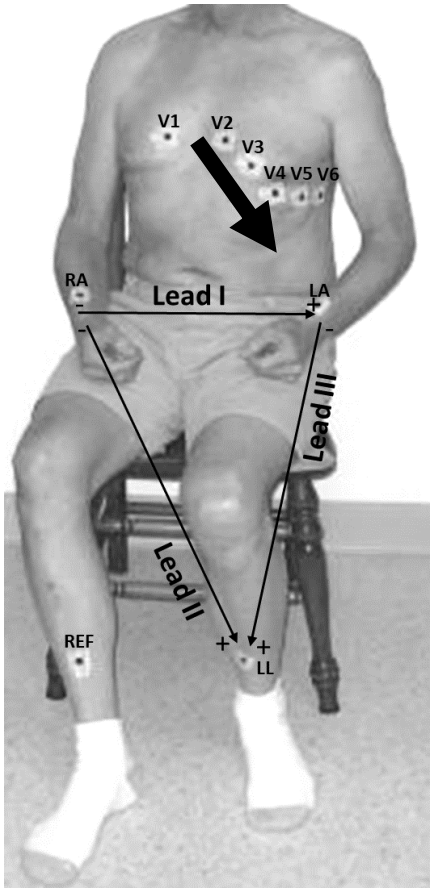
R-wave → 1st positive deflection

S-wave → a negative deflection that follows an R-wave

Normal EKG 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

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

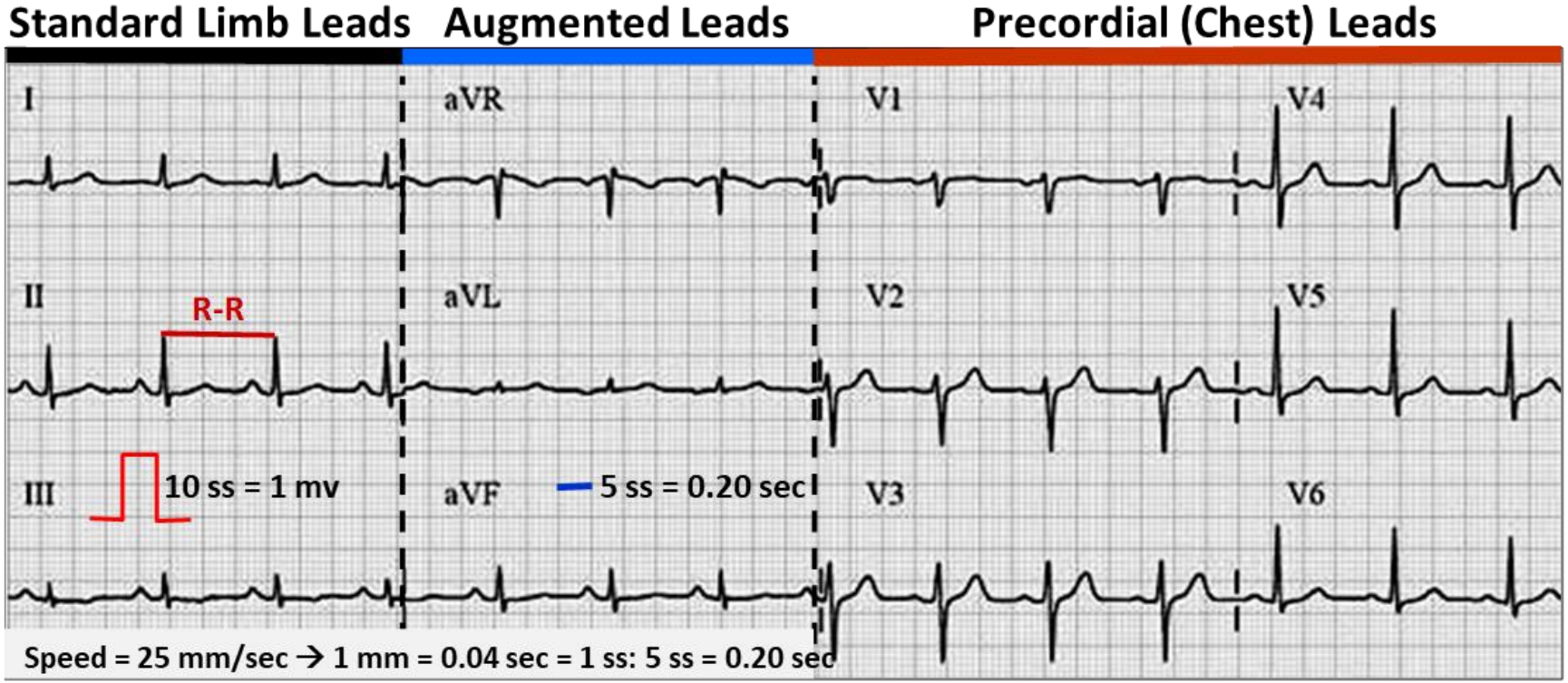
Lead selector and amplifier

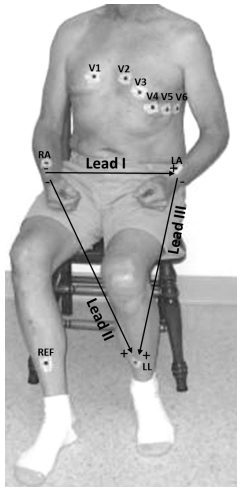
Chart Recorder

Left Leg
LL

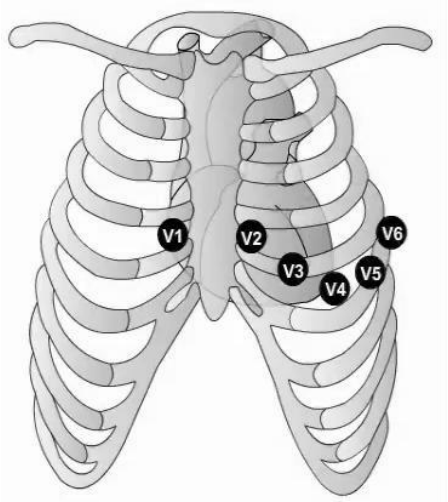
Reference Ground Electrode

Normal 12-lead EKG

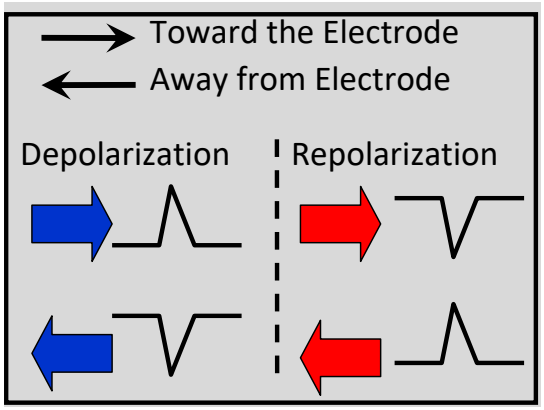


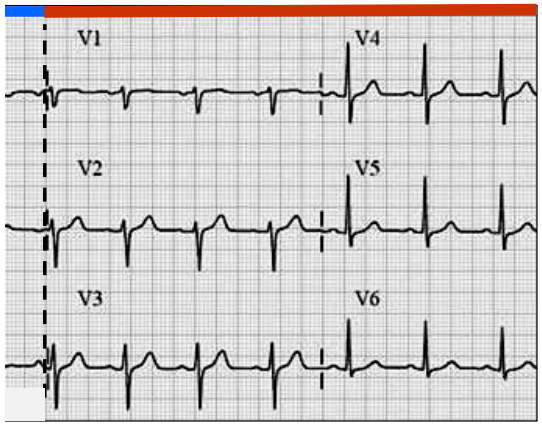


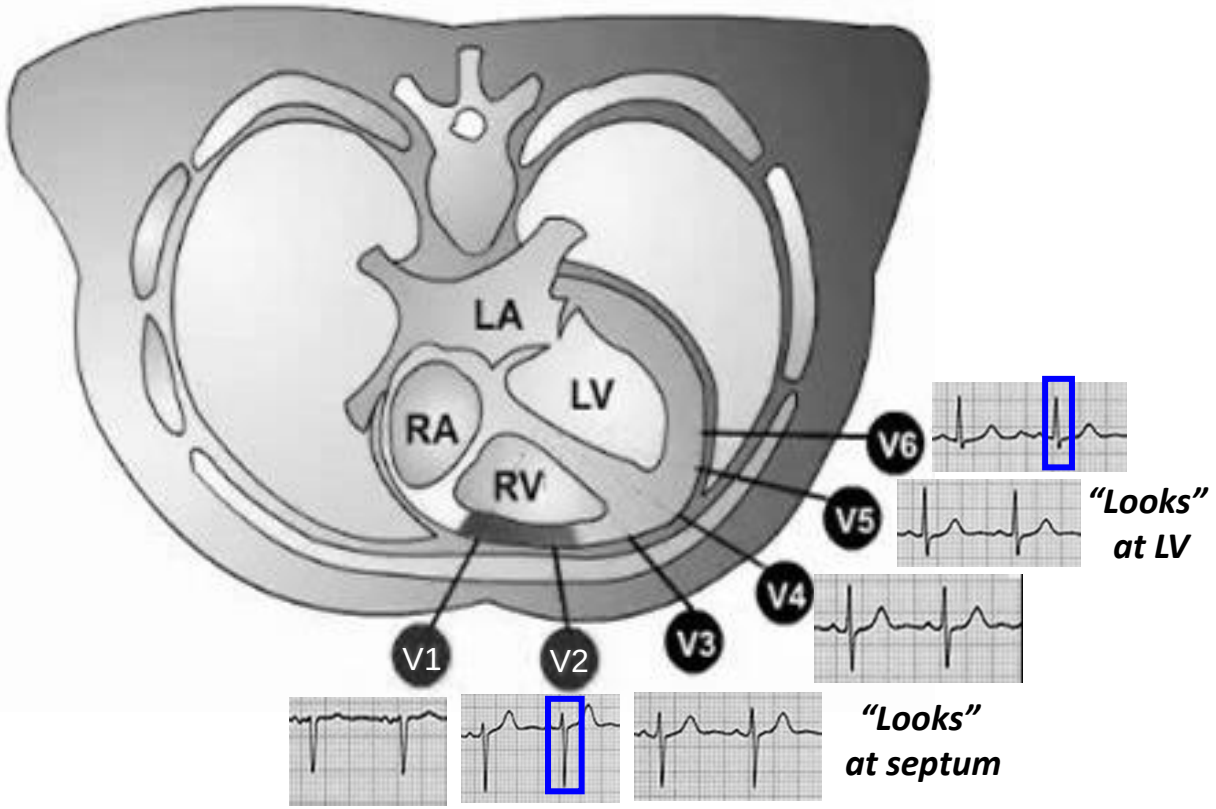
Time Standard Calibration
Speed = 25 mm/sec
1 mm = 0.04 sec = 1 ss
5 ss = 0.20 sec
Amplitude Calibration
10 ss = 1 mv



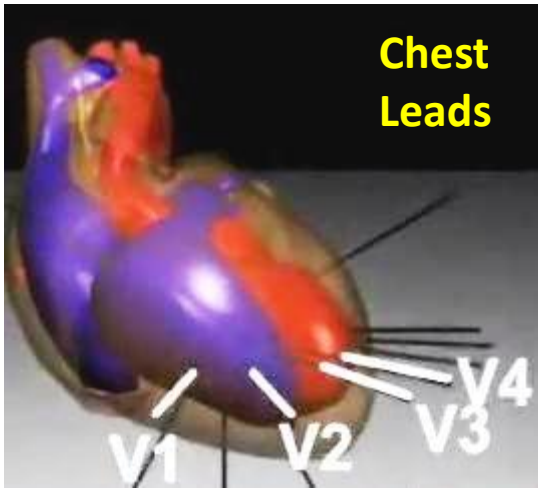
Chest (Precordial) Leads: EKG Deflections

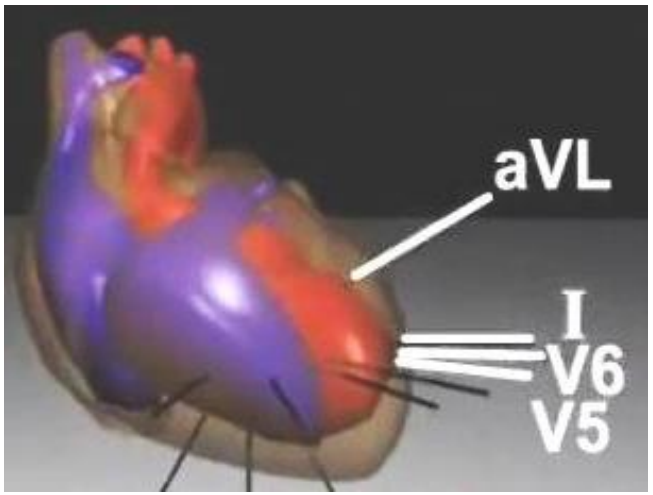






Chest and Limb Leads: Sensed Territories

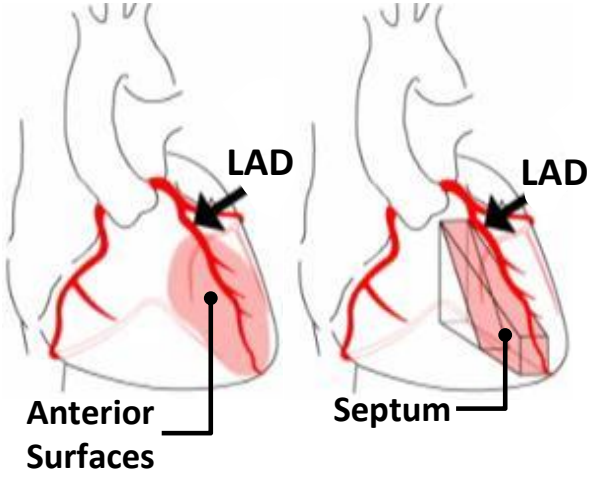


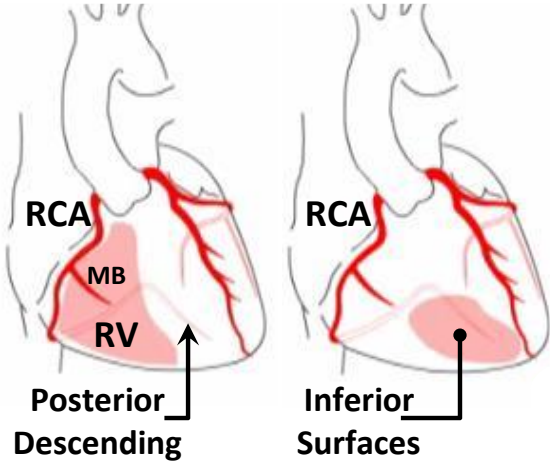


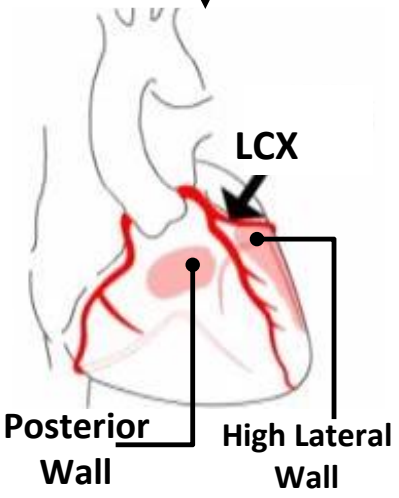
Anterior V1→V4

Inferior III aV_F II

Left Lateral aV_L I V6 V5



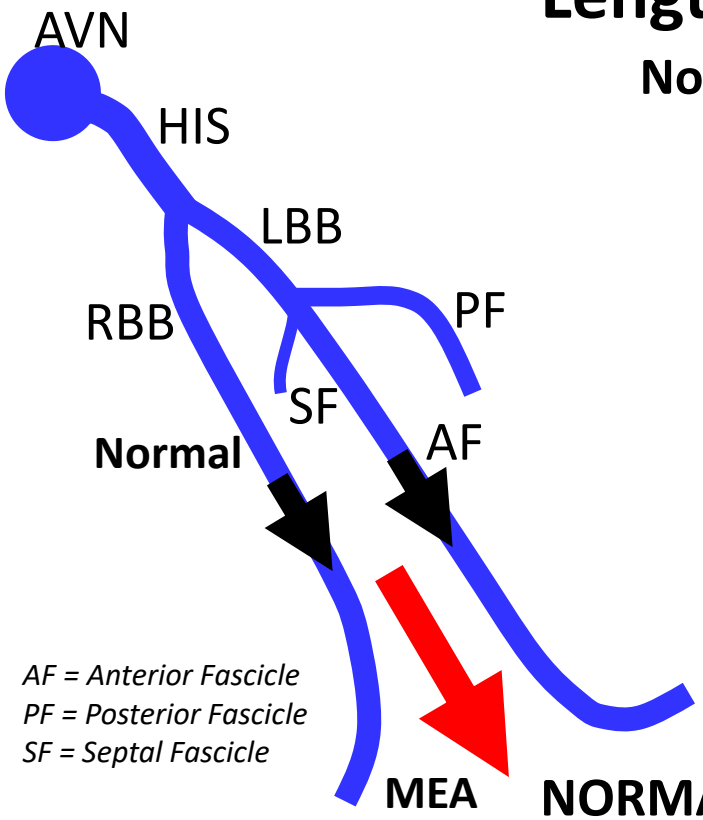




Conduction Blocks: 1º

Lengthened PR Interval

Normal PR: 0.12 – 0.2 s

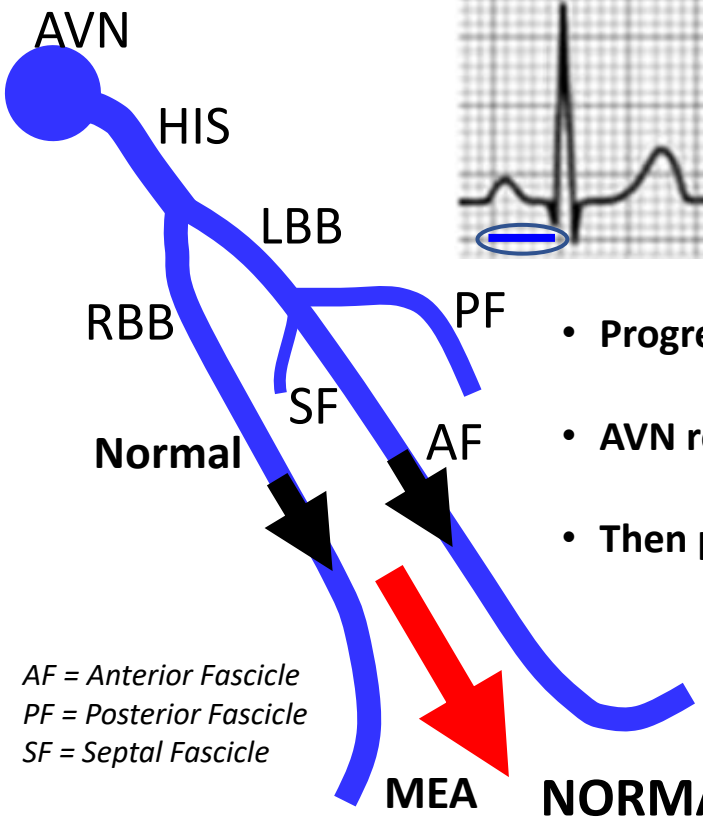


AF = Anterior Fascicle
PF = Posterior Fascicle
SF = Septal Fascicle

IF PR consistently > 0.2s = 5 ss then 1º block

Often issue is with AVN

Conduction Blocks: 2º



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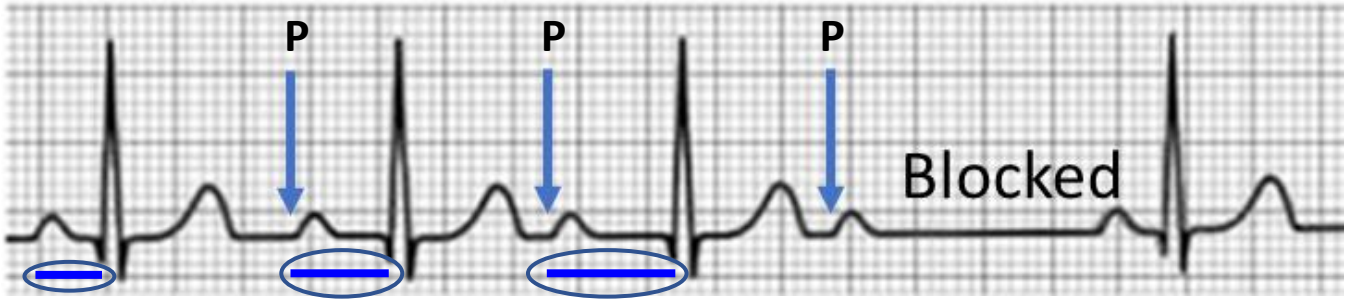
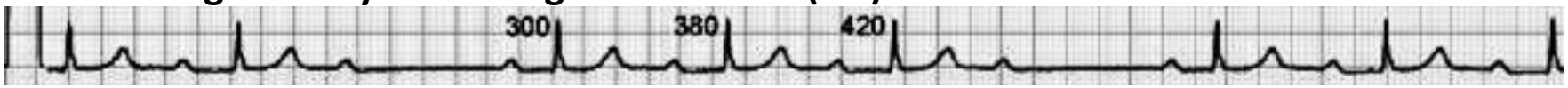


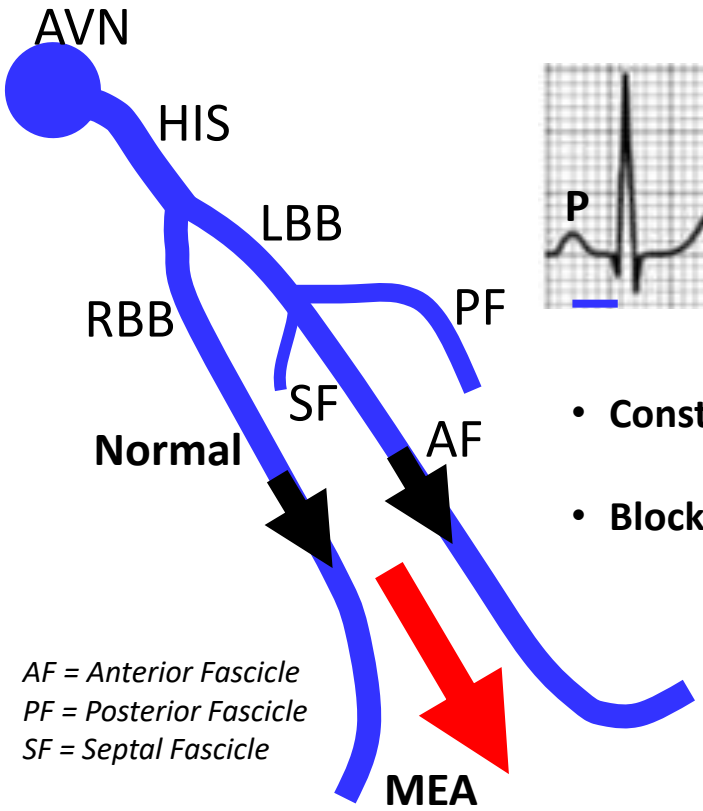
- **Progressively increasing PR interval until a QRS does not occur**
- **AVN recovery time progressively increasing until refractory**
- **Then pattern repeats**

Mobitz 1 / Wenckebach

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



Conduction Blocks: 2º



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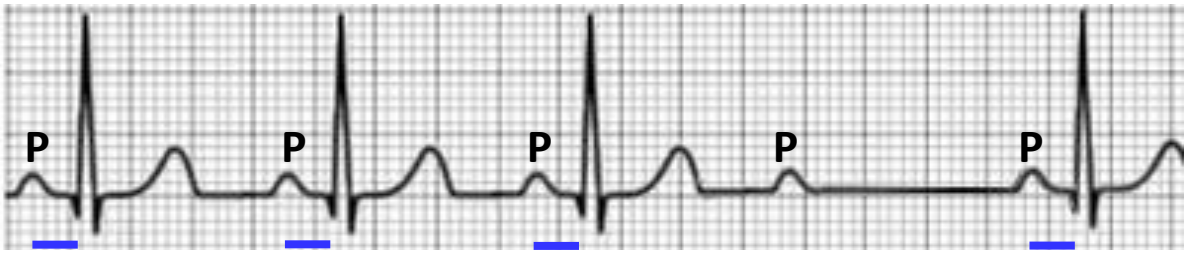
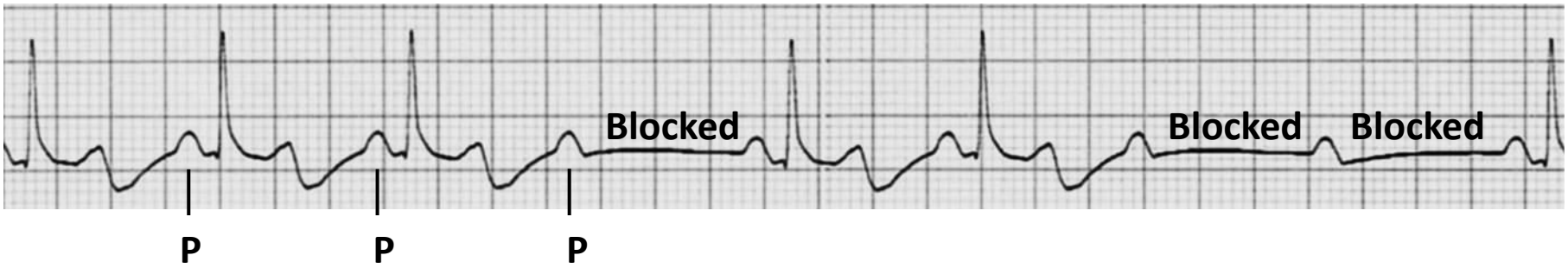


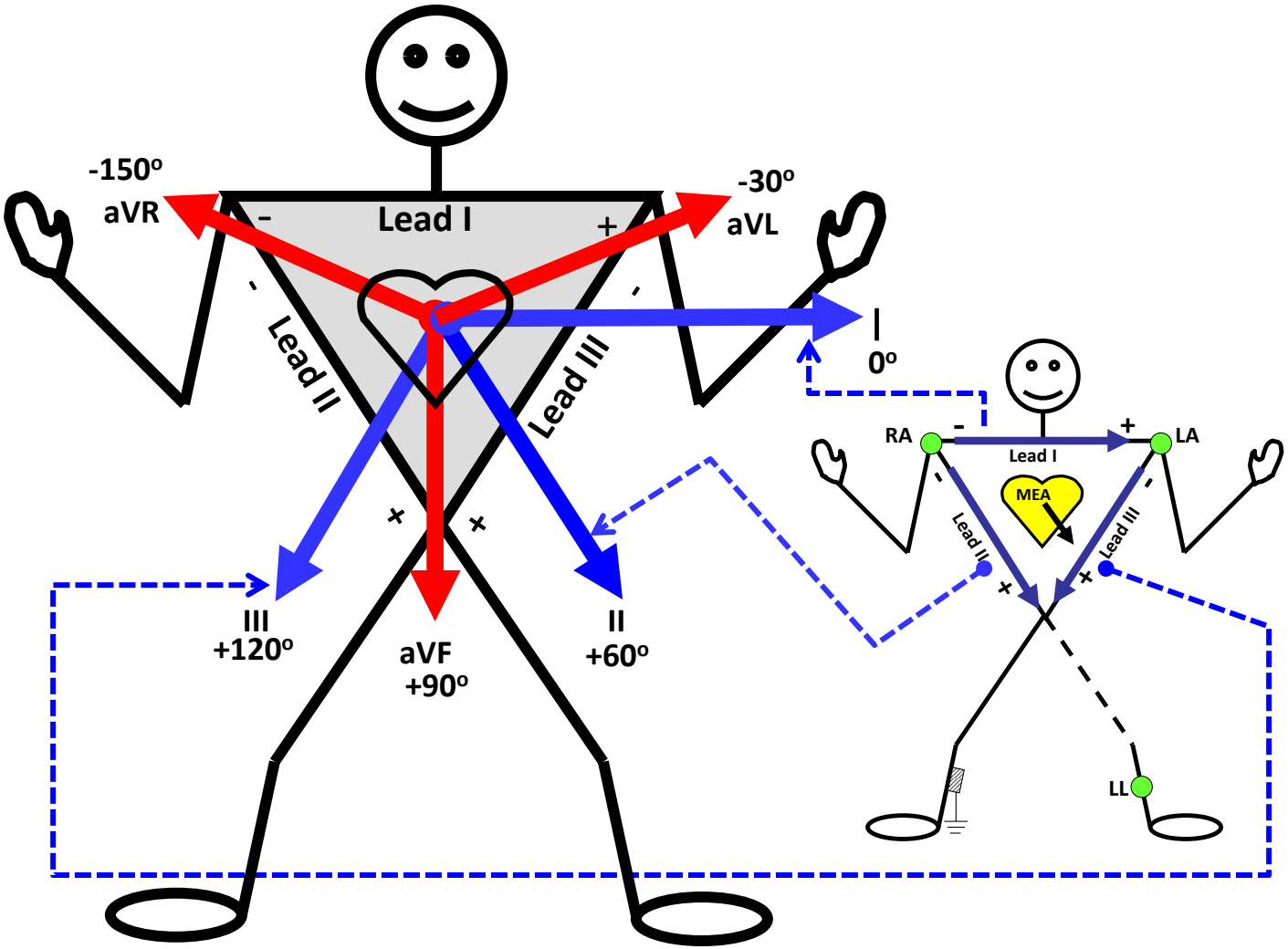
- **Constant PR intervals with Intermittent drop of QRS after a P-wave**
- **Block almost always below the AV (In the His-Purkinje system)**

Mobitz 2 / Hay

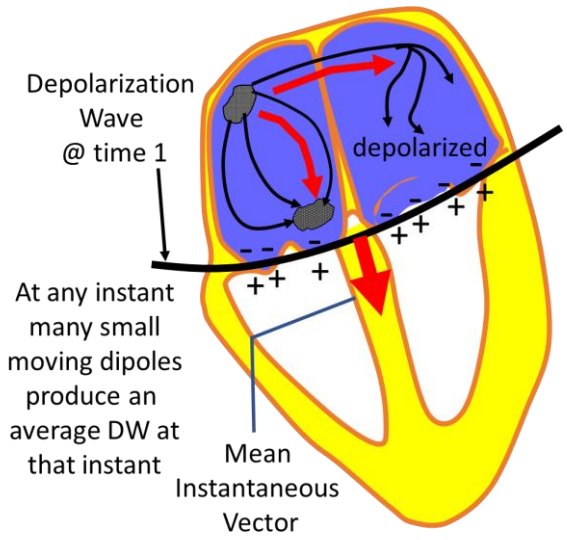


Leads and Axes

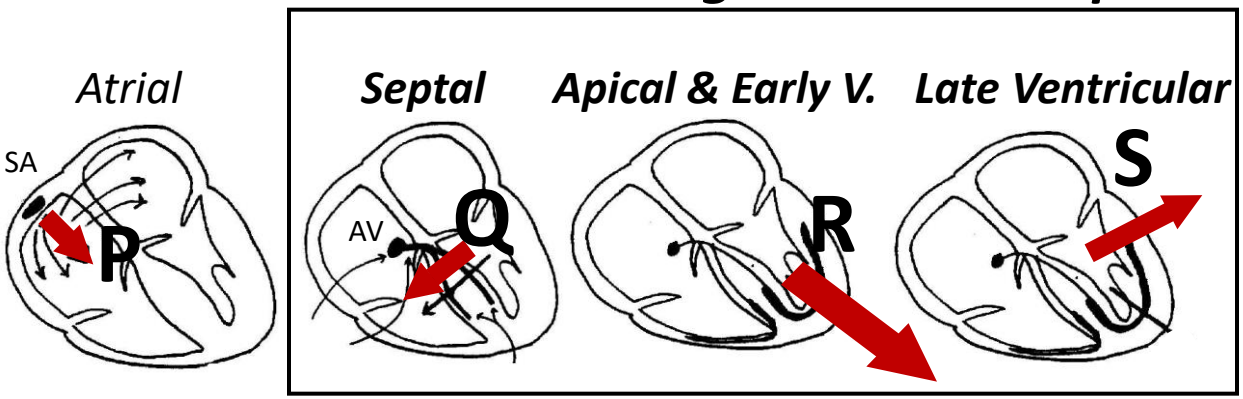
Frontal Plane Leads and Axes



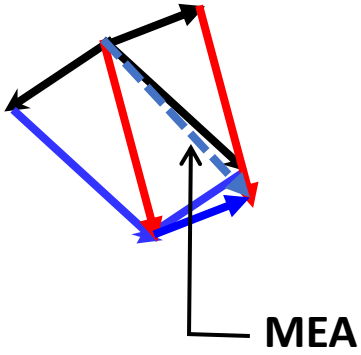
QRS Vector = Mean Electrical Axis (MEA)



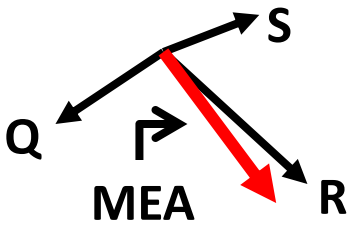
Occur During the QRS Complex



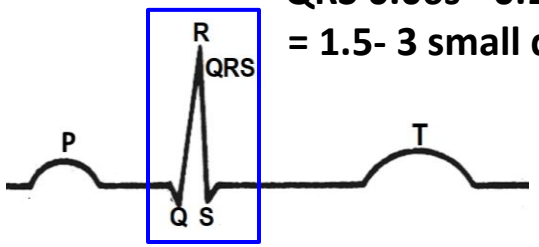
Adding Components



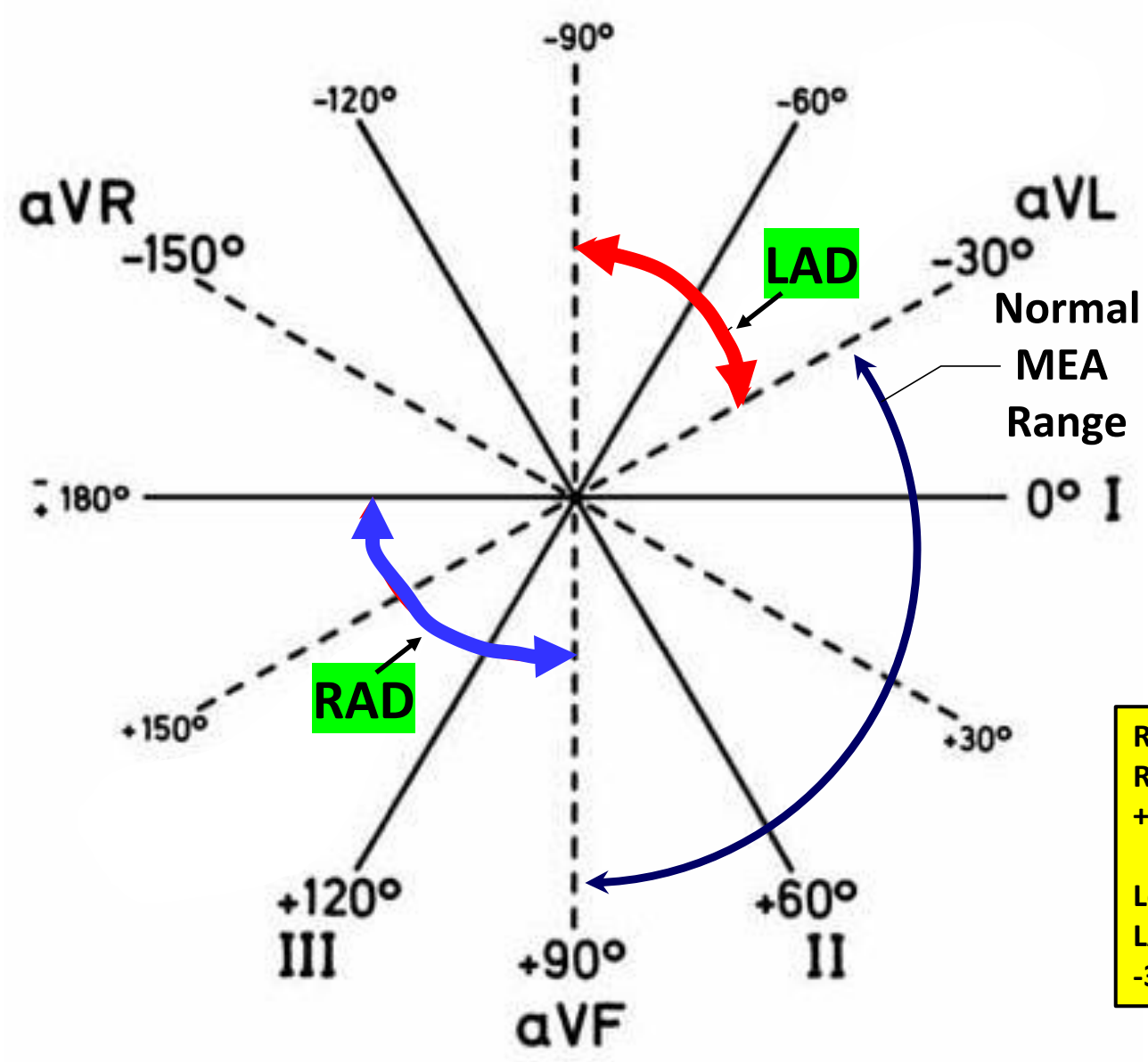
Vector addition determines MEA



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



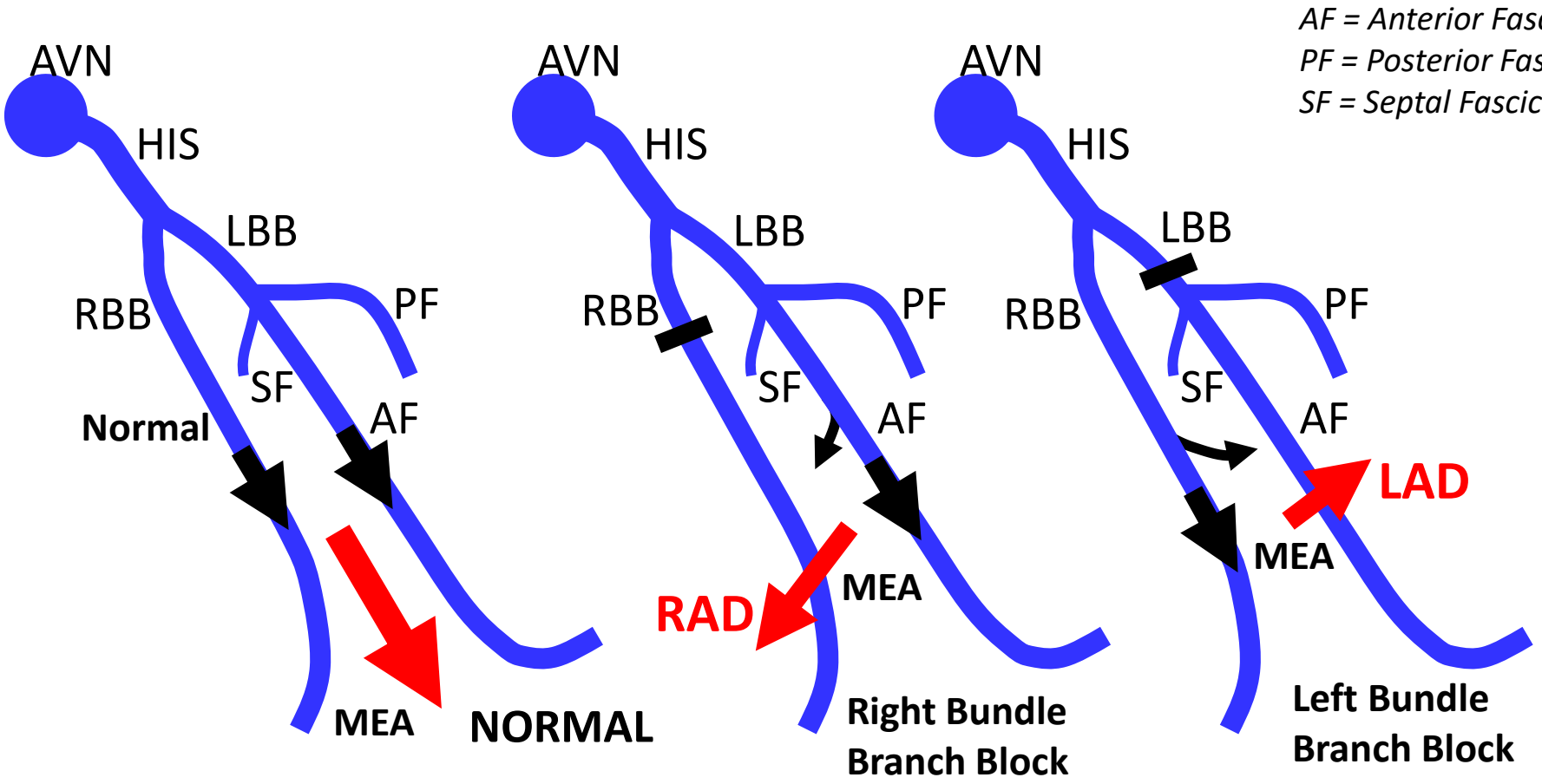
Axis Deviations



Right Axis Deviation
RAD if MEA beyond +90 to +180

Left Axis Deviation
LAD if MEA beyond -30 to -90

Conduction Blocks as Source of Axis Deviation

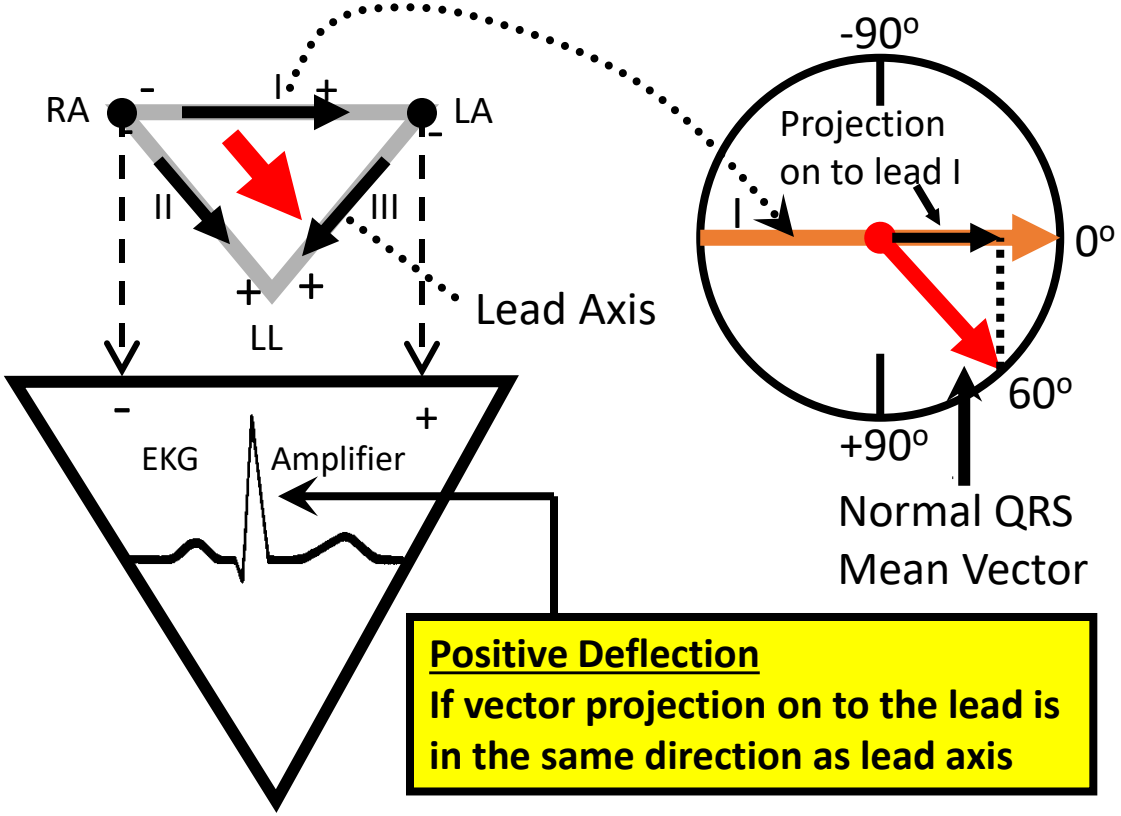


MEA TIDBITS

- **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**

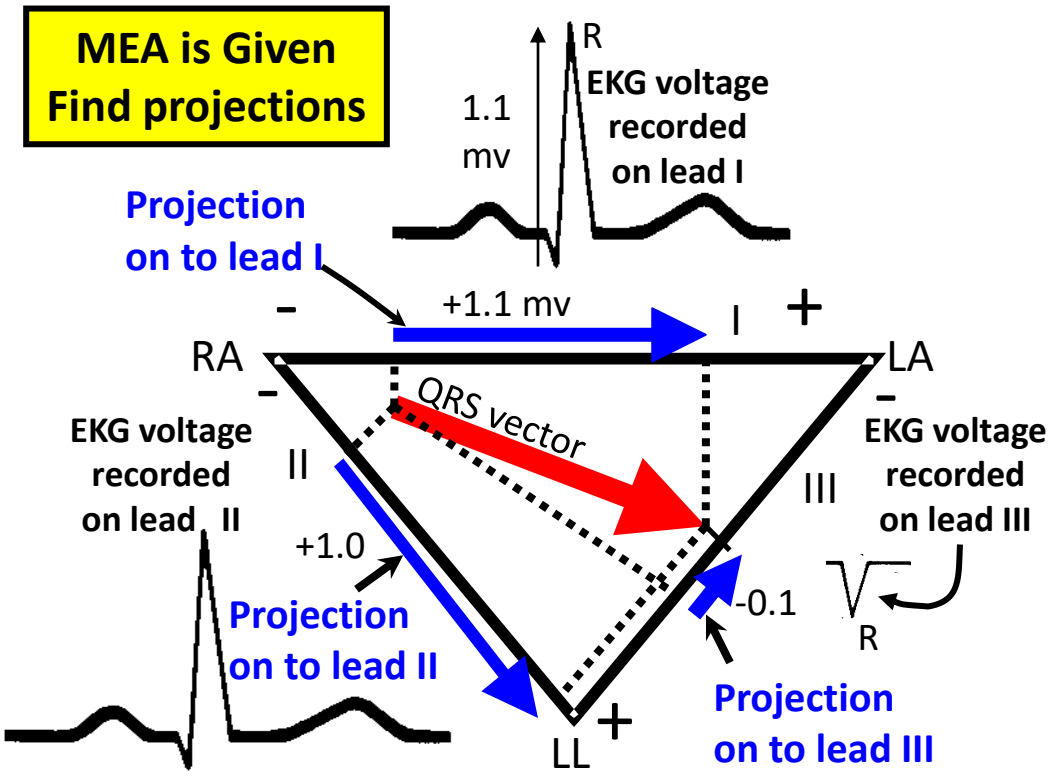
EKG Vector Projection

Cardiac Vector Projection

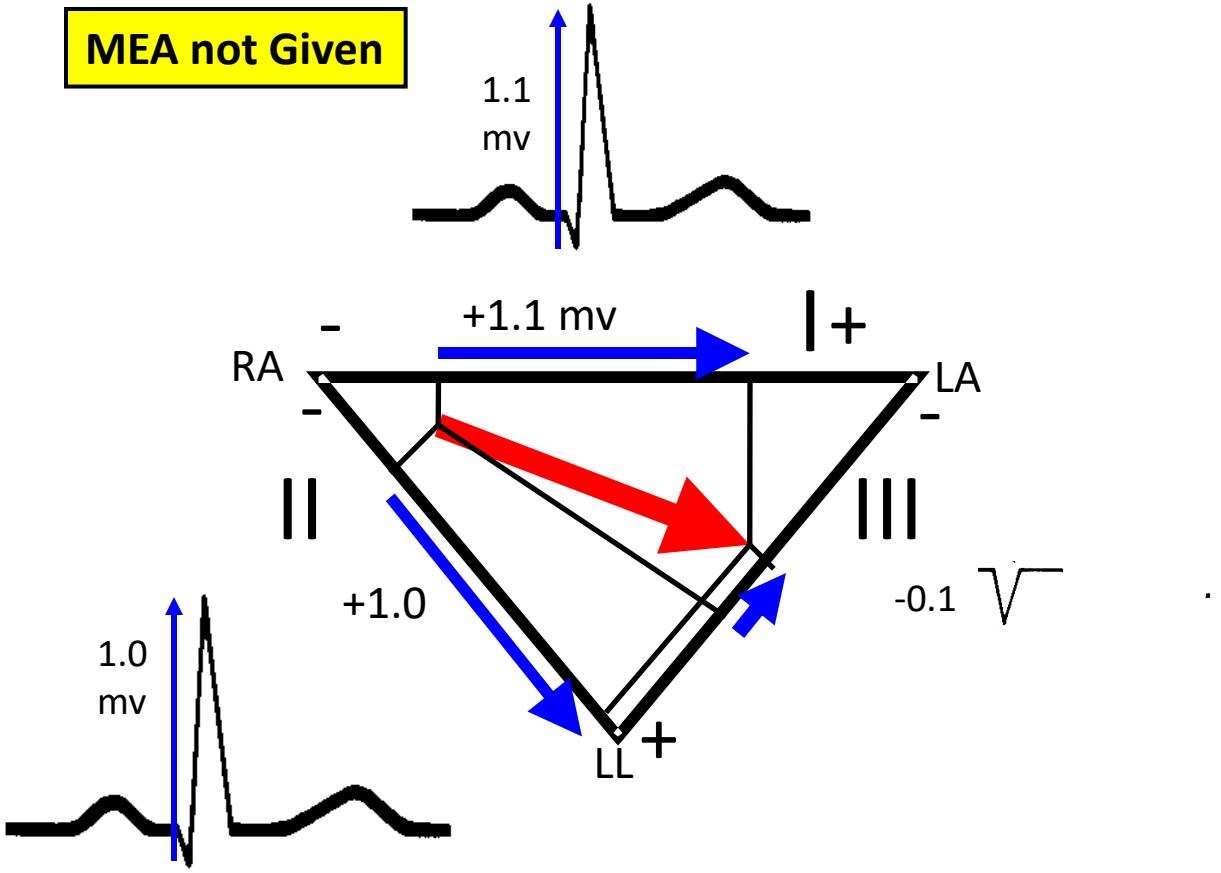


Positive Deflection
If vector projection on to the lead is in the same direction as lead axis

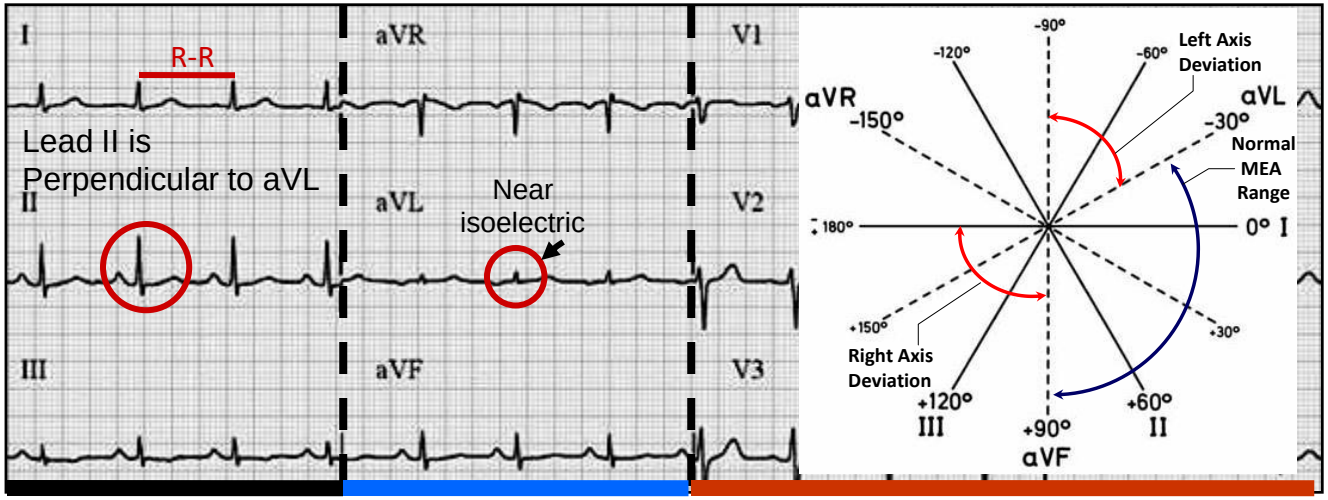
Cardiac Vector Projection Example



Cardiac Vector Projection Example Turned Around



Normal 12-Lead EKG – *Determine MEA*



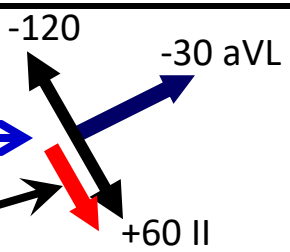
Standard Augmented Precordial

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

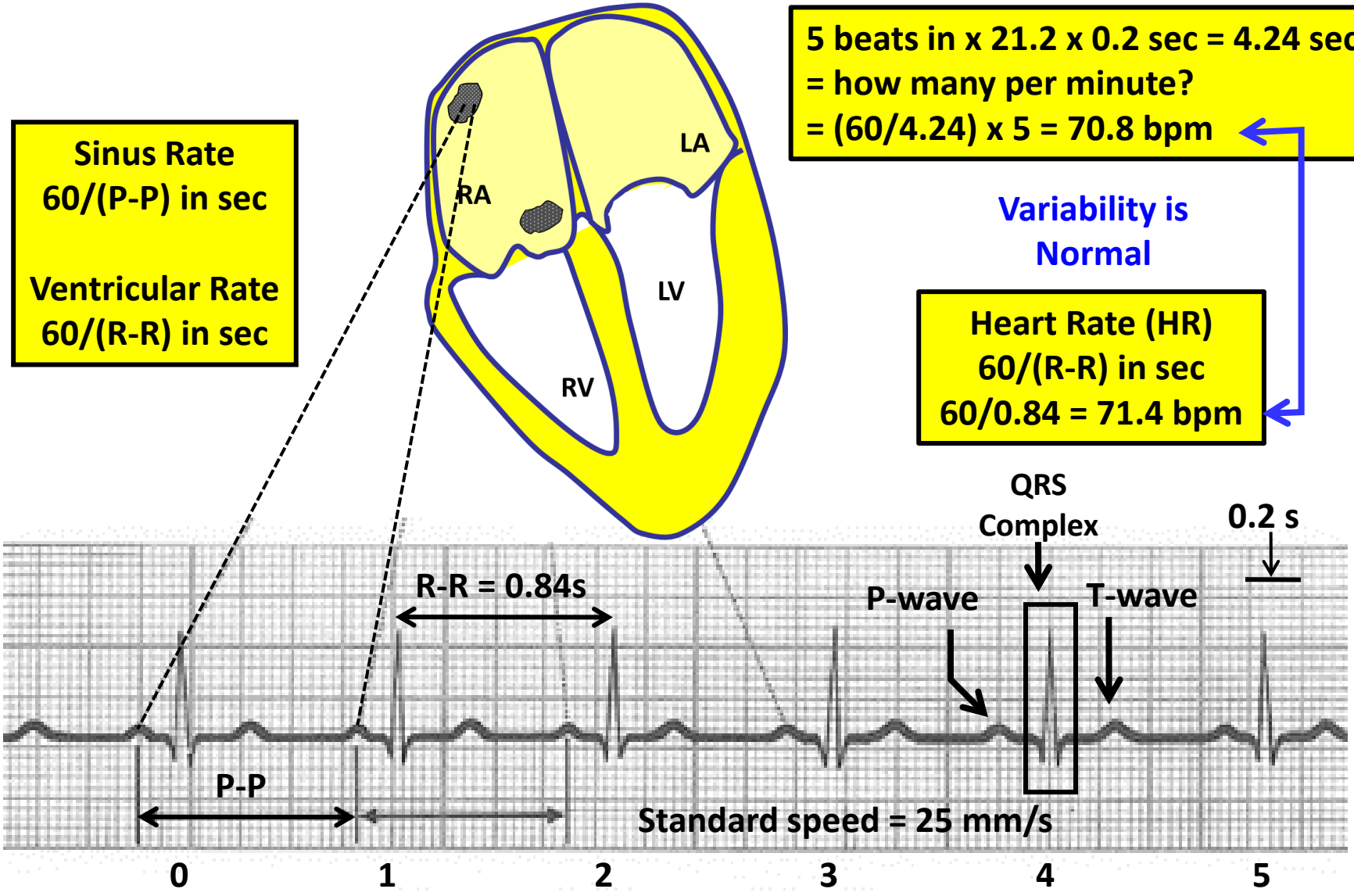
Therefore MEA is ~ 60° or -120°

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

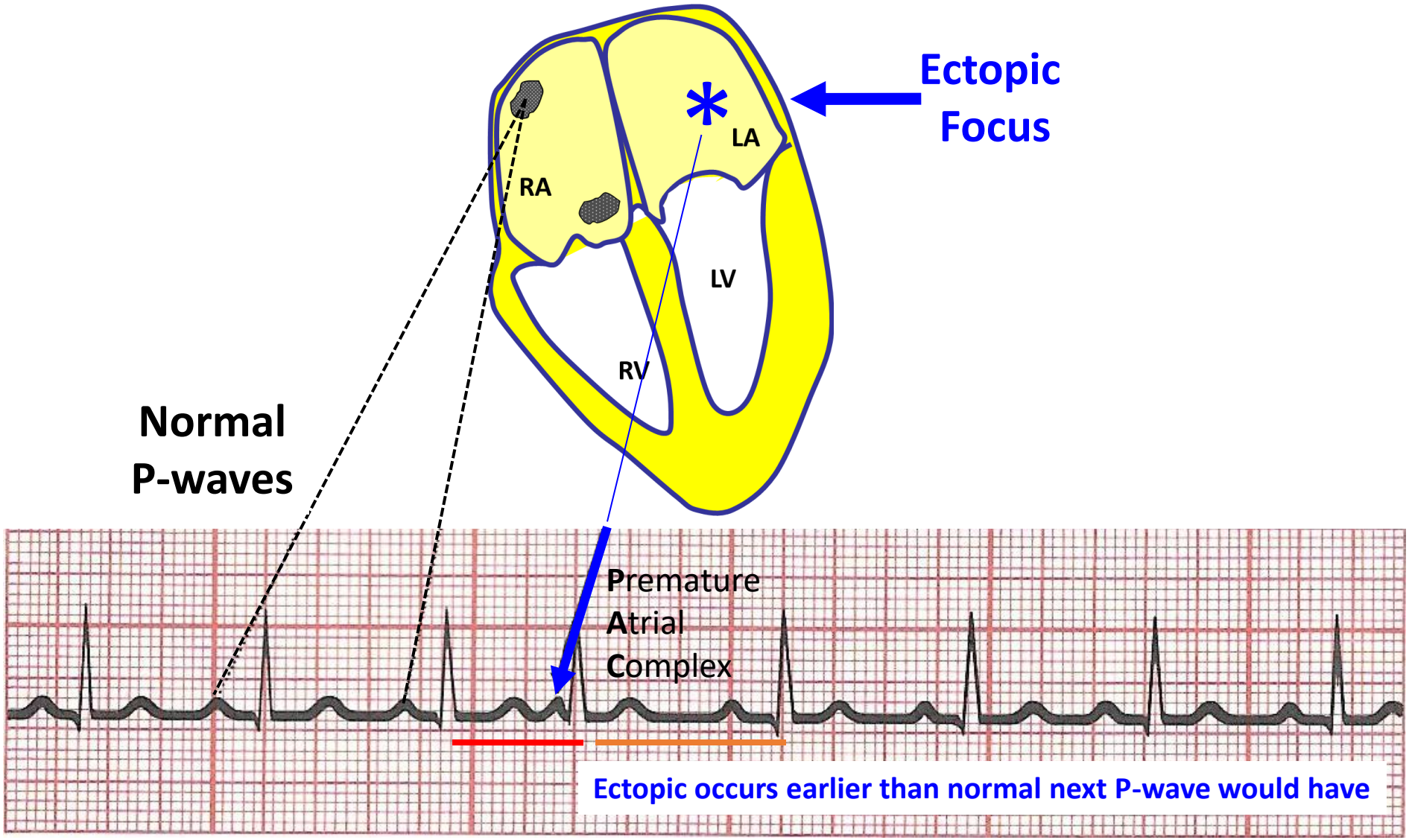


EKG Patterns
Normal and Not-So-Normal
(as time permits)

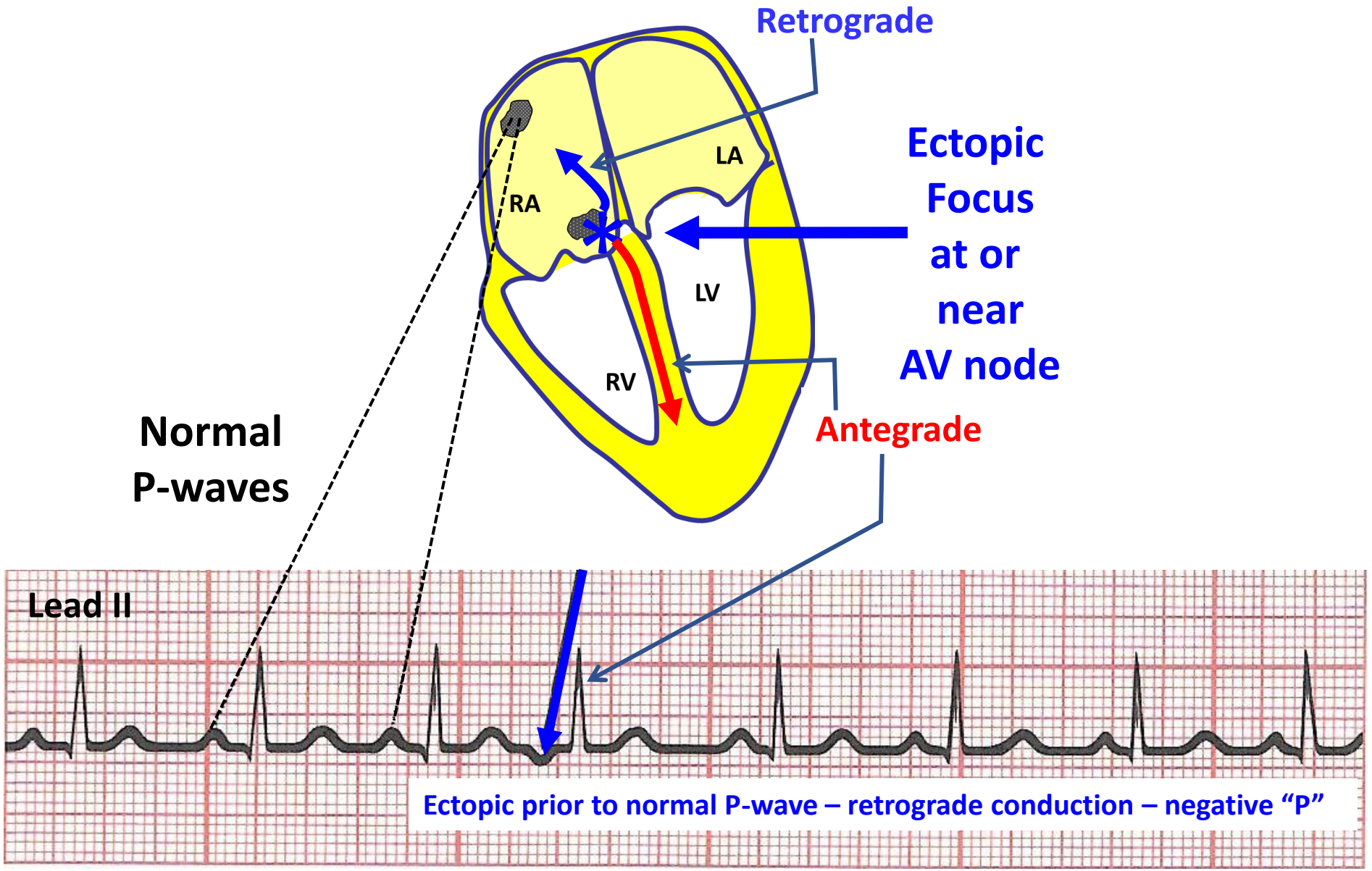
Normal


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

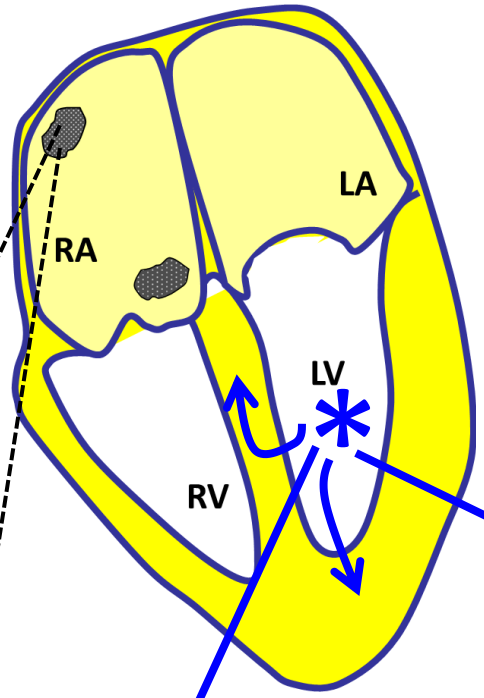
Atrial Ectopic Impulse – Early



Ectopic Impulse – Negative P-Wave



Ectopic Impulse – Ventricular

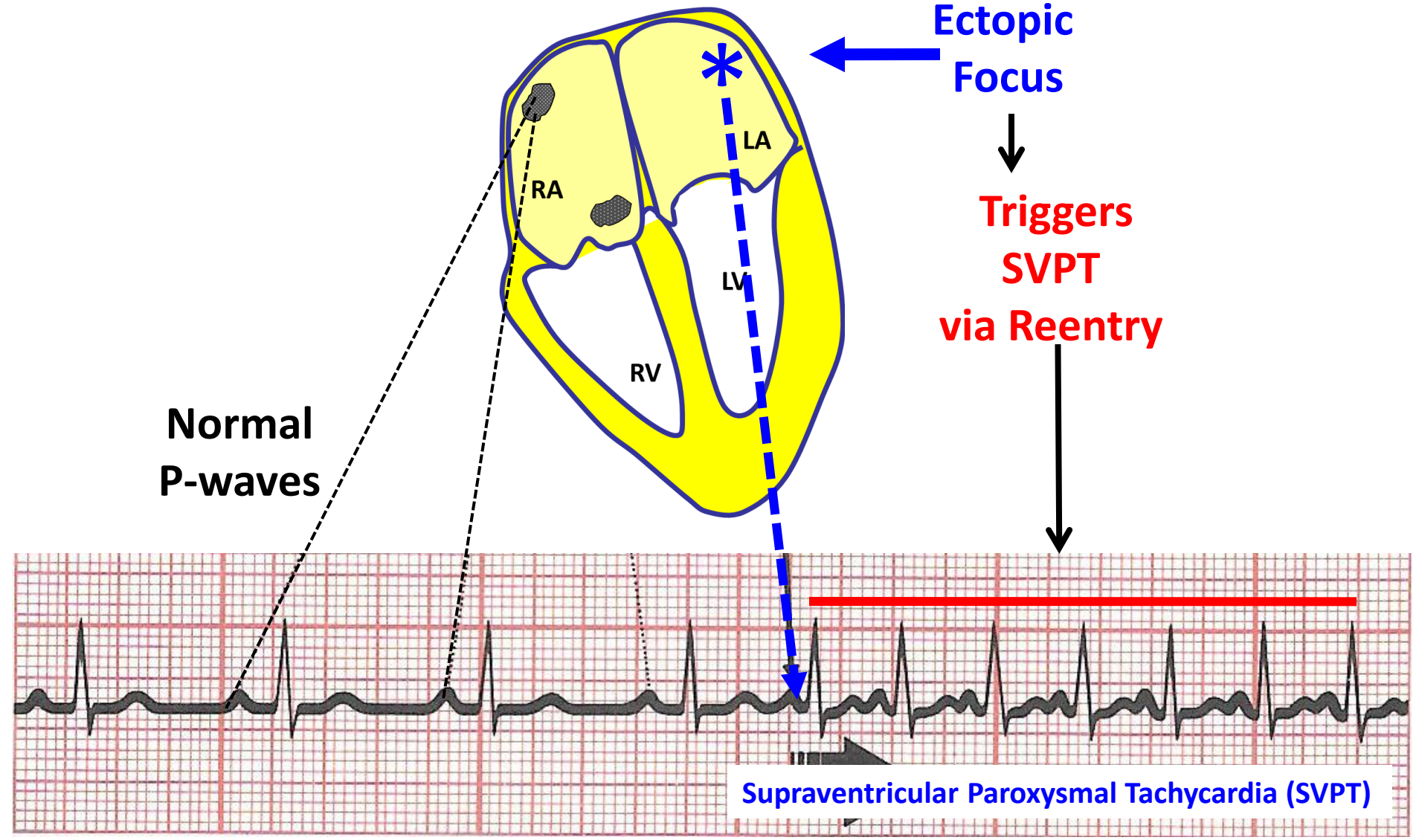


Ectopic Focus in ventricle muscle or conduction pathway

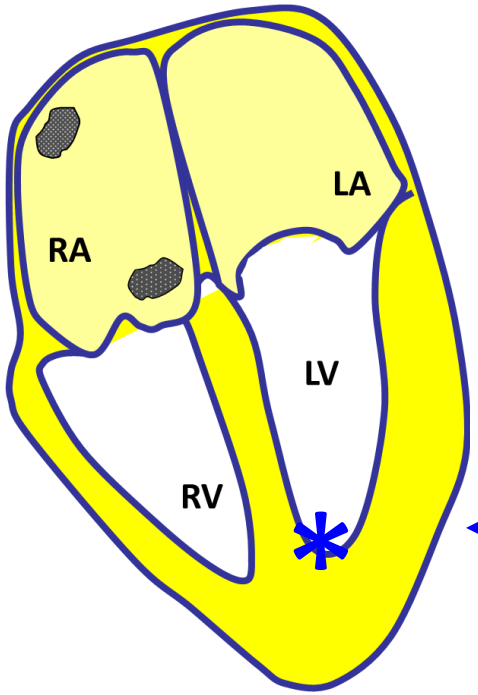
Normal P-waves

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

Supraventricular Paroxysmal Tachycardia

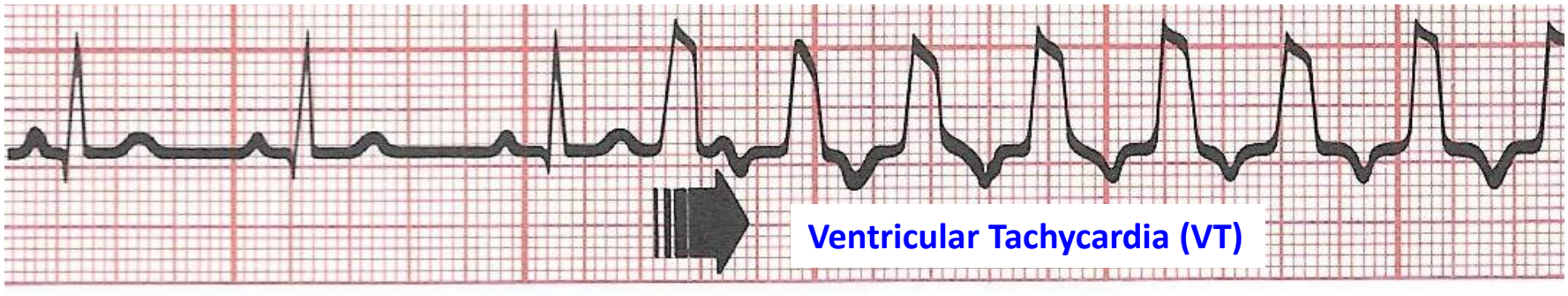


Ventricular Tachycardia

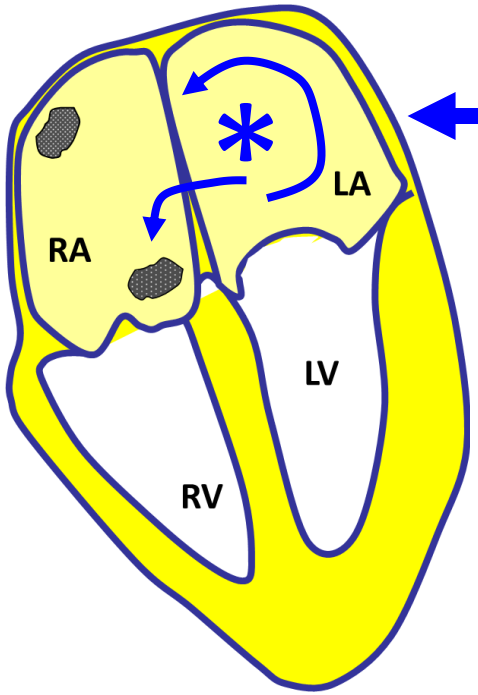


Ectopic Focus Ventricle Triggers VT

HR ~ 60/0.4 = 150 bpm



Flutter Waves



Ectopic Focus With Reentry and Re-excitation

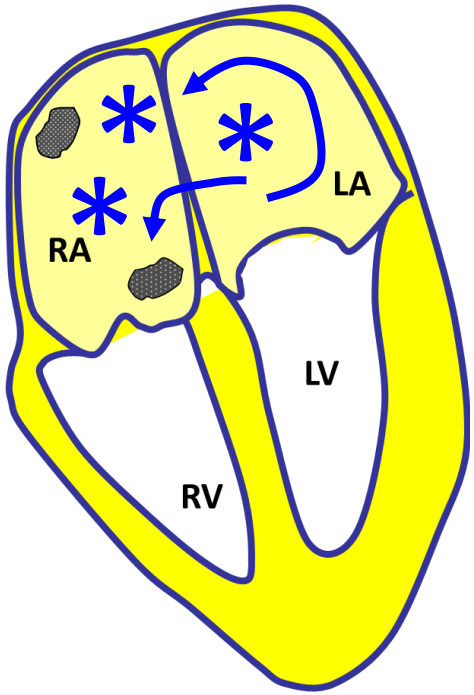
"Flutter Waves"

0.6 s

HR = 60/0.6 =100

Atrial depolarizations not passing through AV

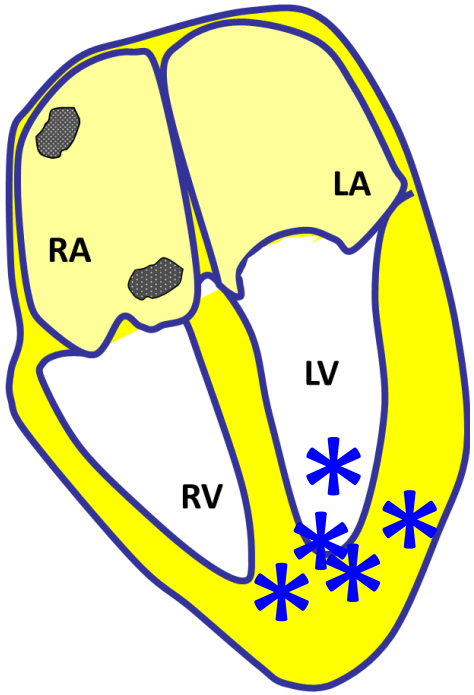
Atrial Fibrillation



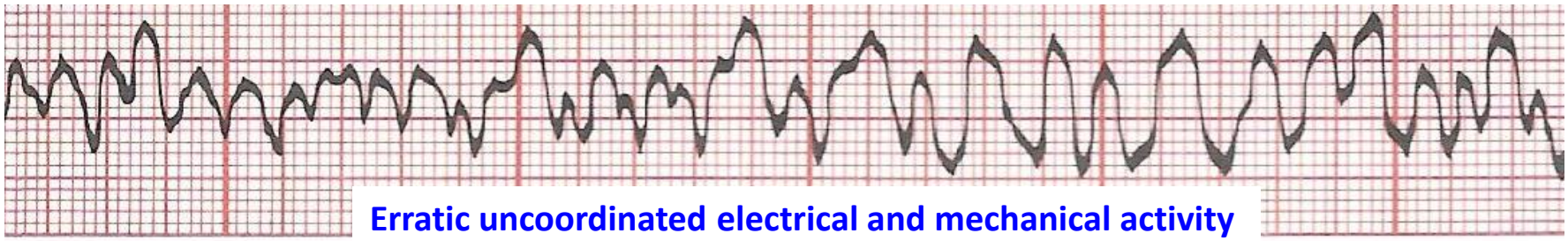
MULTIPLE Ectopic Foci causing uncoordinated impulse transmission through AVN

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

Ventricular Fibrillation



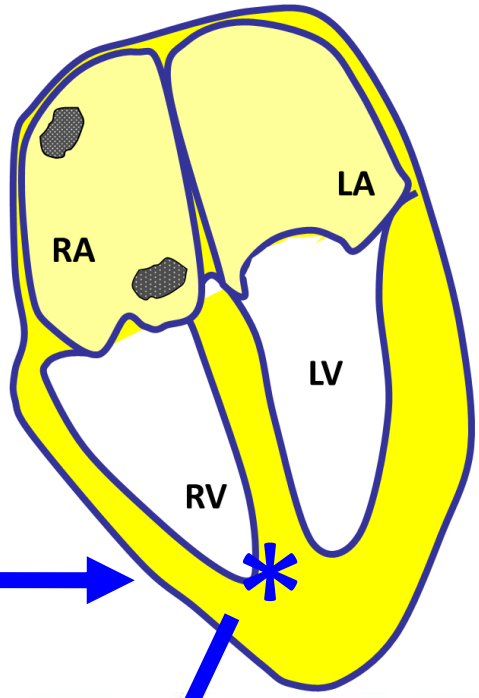
MULTIPLE Ectopic Foci



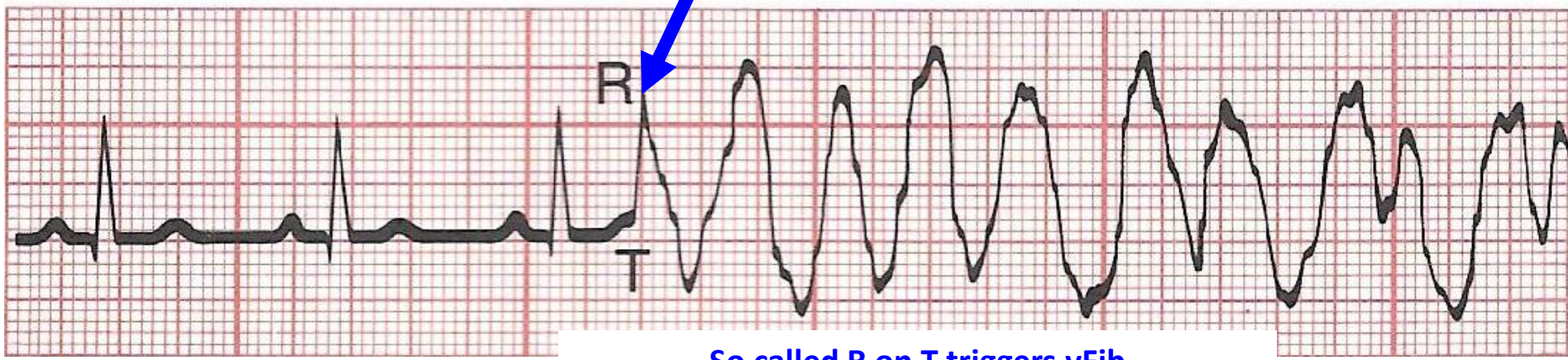
Erratic uncoordinated electrical and mechanical activity

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 CV Physiology Lecture 3

Dr HN Mayrovitz