“Beat It”:

Understanding Arrythmias

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SBHPP 2024

agenda

Cardiac Anatomy

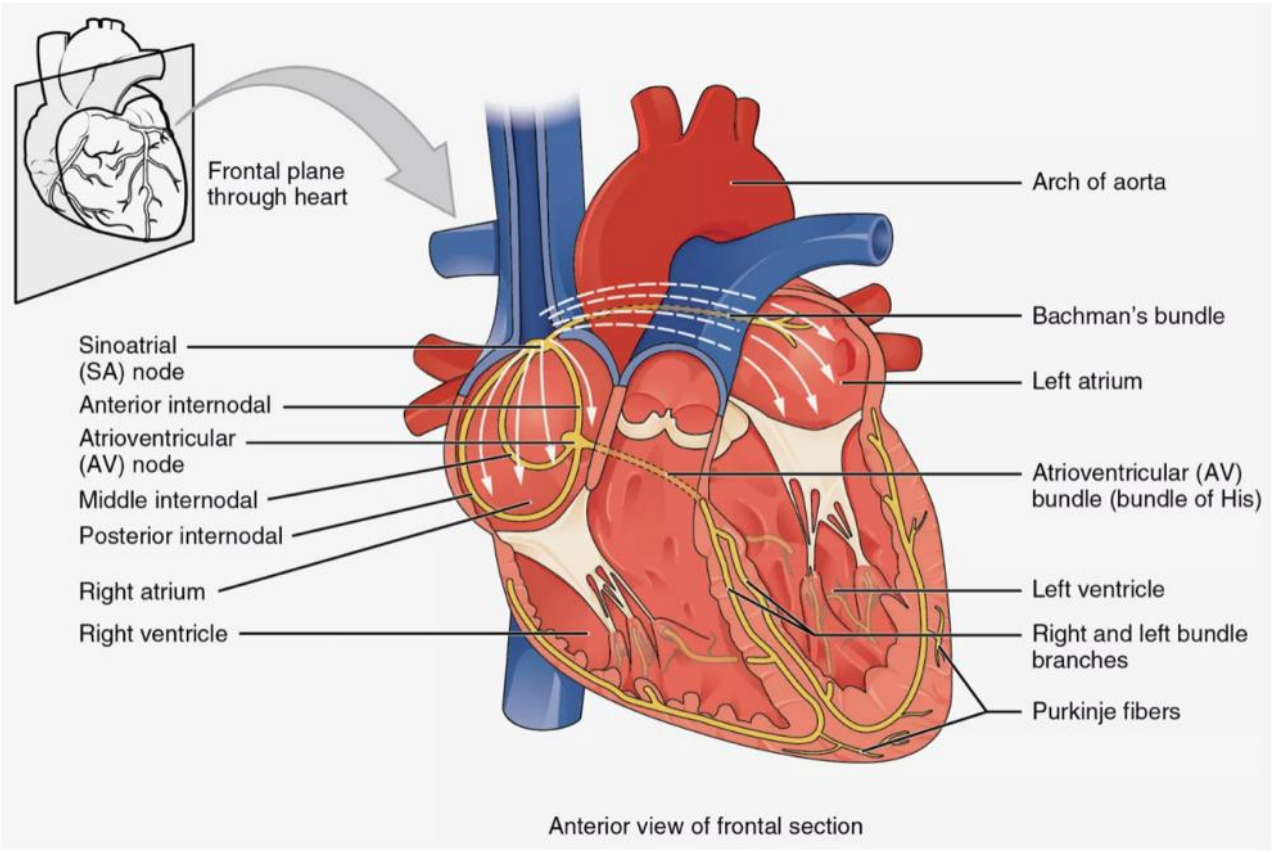
Cardiac Physiology

Cardiac Pharmacology

What is “Normal”

What is “Abnormal”

REVIEW: Signals to Squeeze

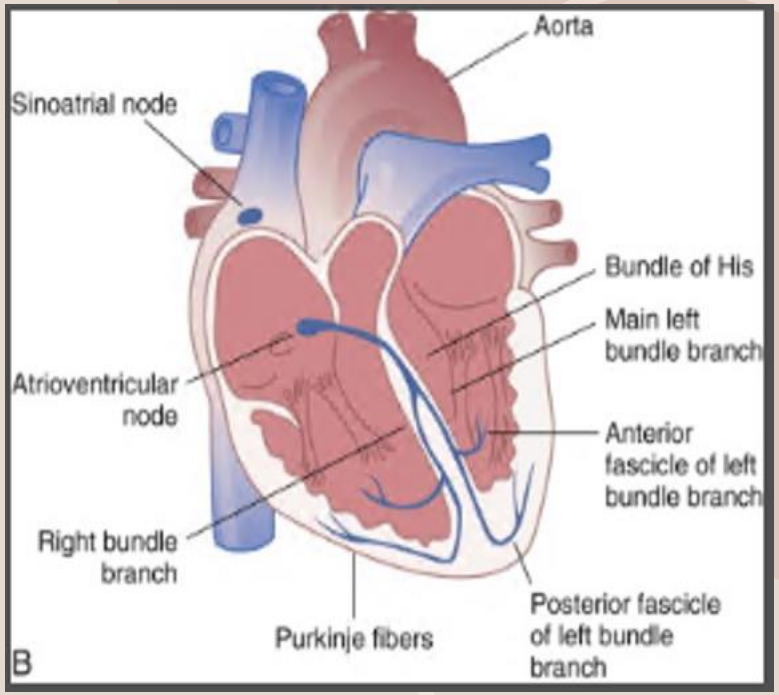


- SA regulated by the **autonomic nerves** of peripheral nervous system
  - Parasympathetic and sympathetic autonomic nerves send signals to the SA node
    - Speed up (sympathetic) HR
    - Slow down (parasympathetic) HR
- SA to AV impulses have 1/10 sec delay (during which atria contract, dump blood into ventricles)
- AV sends impulses to ventricles via bundle of His through left and right bundle branches to Purkinje fibers

Image source: https://www.thoughtco.com/heart-nodes-anatomy-373242

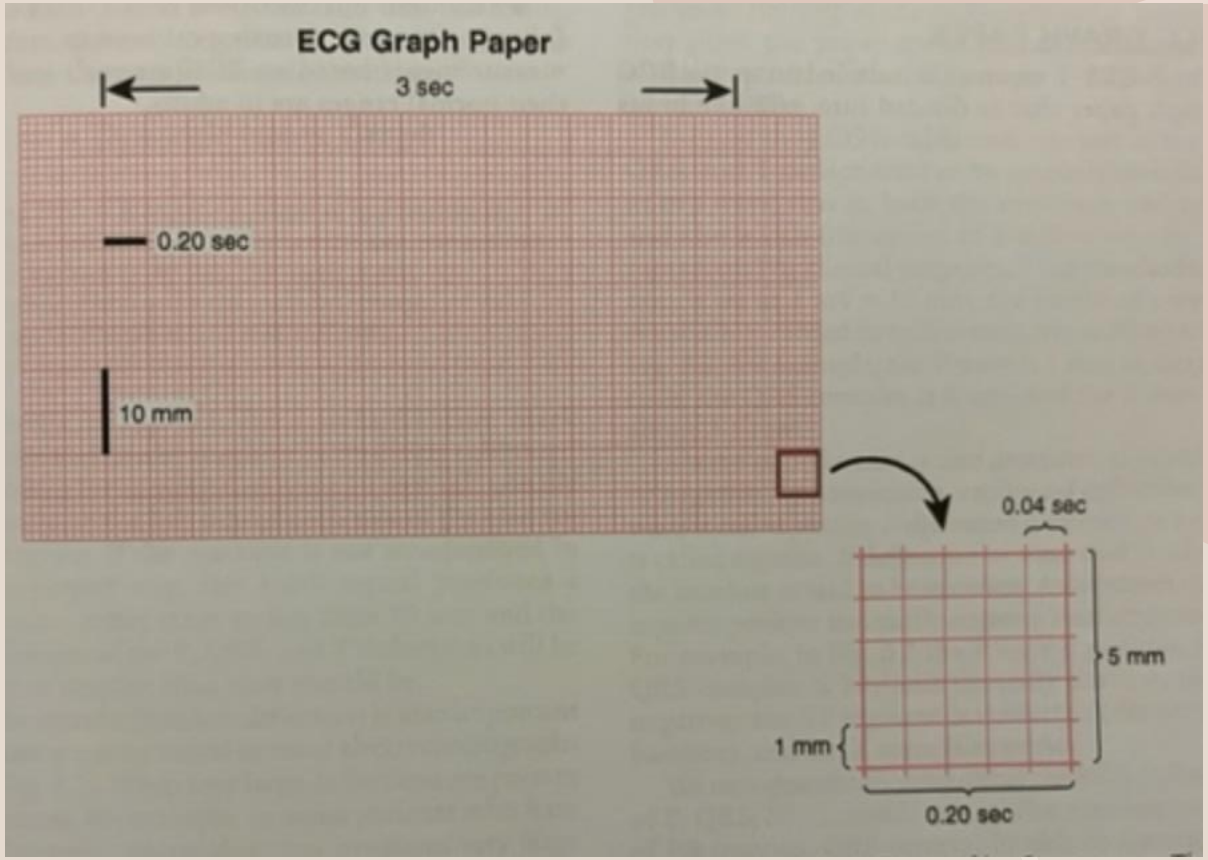
REVIEW: Conduction System

- Sinoatrial (SA) node:
  - Specialized pacemaker cells, in the RA between the SVC and the RAA
  - Gets blood from a branch of the RCA (60% of the population) or a branch of the LCx (40%)
  - Electrical impulse from SA goes to AV node via tracts within the atria
- Atrioventricular (AV) node:
  - Located at inferior aspect of RA, between the coronary sinus and the TV
  - Gets blood from a branch of the RCA (90% of the population) or a branch of the LCx (10%)
- Electrical impulse goes from AV node through His-Purkinje system to ventricles
  - Divides into the LBB and RBB and ends at the Purkinje cells
- Purkinje cells:
  - ~~Stimulate myocytes to contract or squeeze~~
  - RBB and LBB get blood from branches from the LAD



ECG Graph Paper/Time Intervals

- Each 1 mm “mini” box is 0.04 seconds
- 5 of the mini boxes form a “larger square” and is 0.2 seconds
- 5 larger boxes would be 1 second in duration



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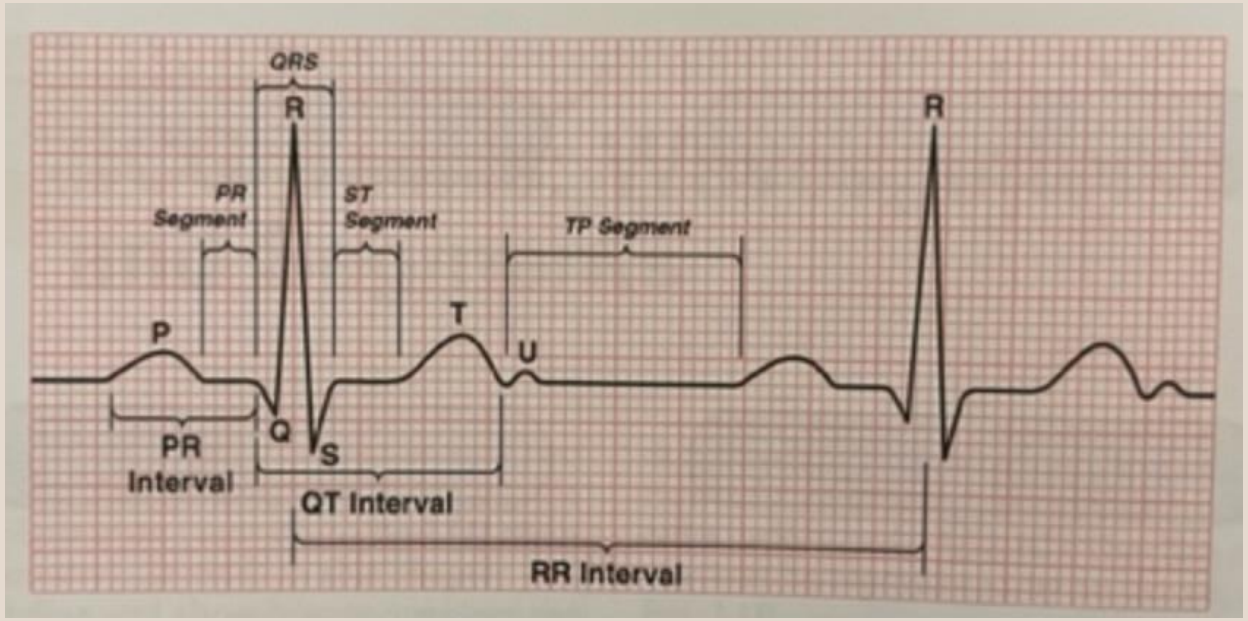
ECG Waveform



3 segments

- PR: atrial repolarization begins (and ends during ST)
- ST: ST-T – ventricular repolarization (NOTE: ST elevation or depression can be seen with MI)
- TP: electrical resting state

4 intervals

- PR
- QRS
- QT/QTc (if corrected for HR)
- PP/RR (QRS-QRS)

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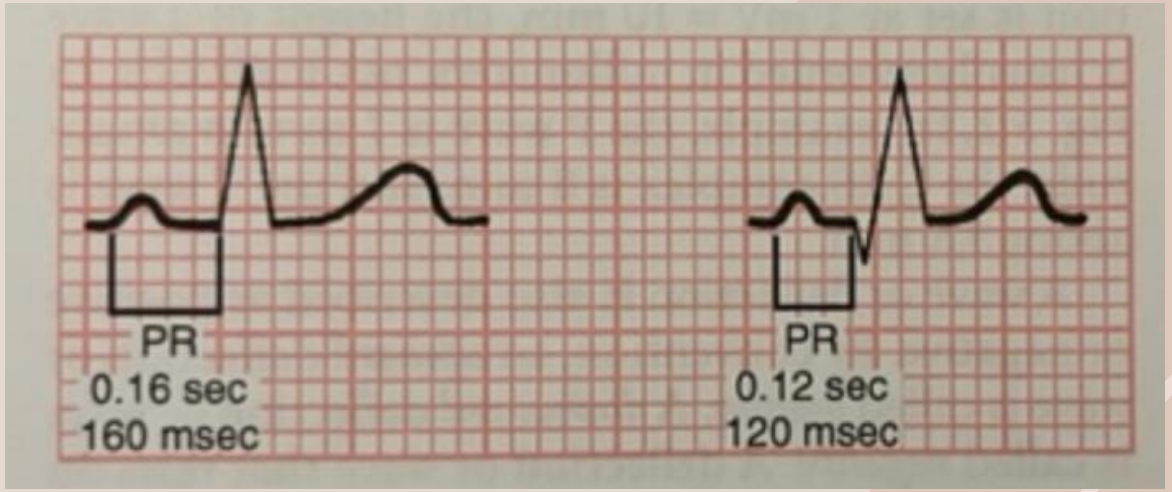
PR Interval



- Remember: each little box is 0.04 sec
- In adults: normal PR = 0.12-0.20 sec (3 to 5 little boxes)

- Conduction through AV junction can be delayed making PR>0.2 sec
  - This is a 1st degree heart block (delayed)

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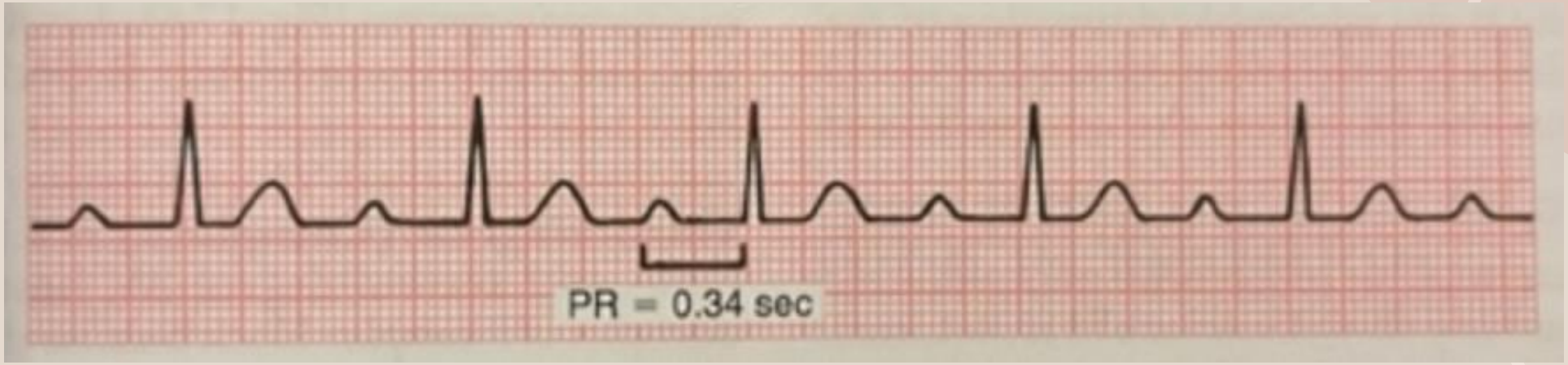
1st Degree AV Block

- First Degree AV Block: The PR interval is longer than 0.2 seconds or one big block on EKG



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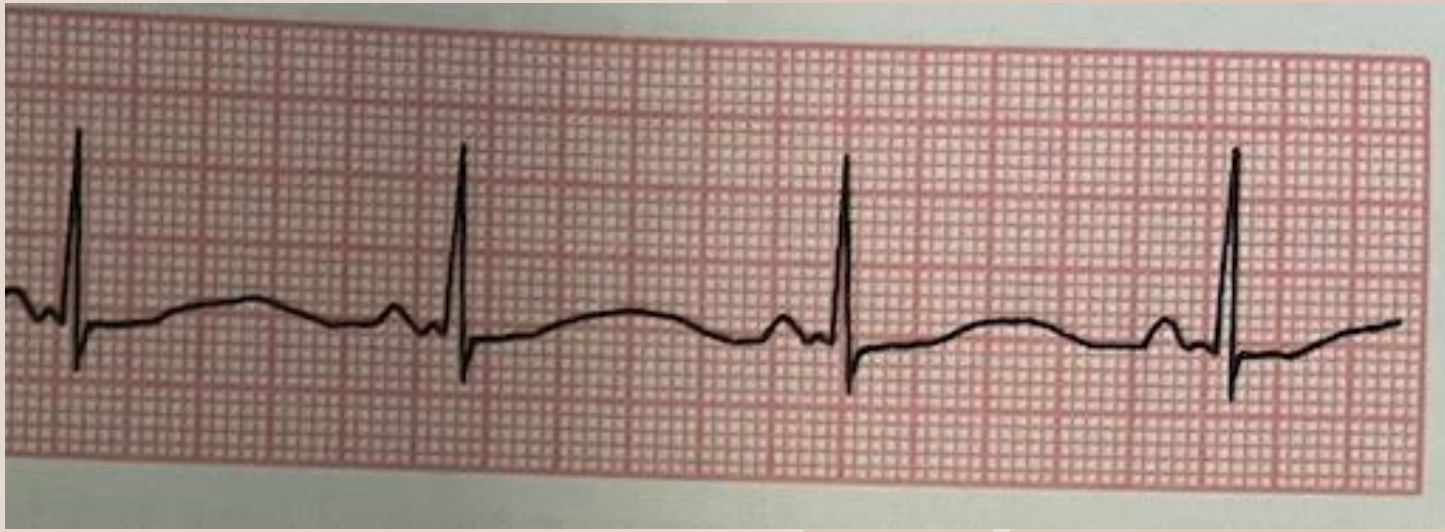
Long QT

TABLE 3.1	QT Interval (Uncorrected): *Approximate* Upper Limits of Normal*	
Measured RR Interval (sec)	Heart Rate (beats/min)	QT Interval Upper Normal Limit (sec)
1.20	50	0.48
1.00	60	0.44
0.86	70	0.40
0.80	75	0.38
0.75	80	0.37
0.67	90	0.35
0.60	100	0.34
0.50	120	0.31



- Practice:
  - What is Heart Rate?
  - 5.4 big boxes, so
  - 300/5.4 = 56 BPM
- What is QT interval?
  - ~3.5 big boxes
  - 0.2 sec * 3.5 = **<u>0.7 sec</u> (so, long QT)**

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How to determine heart rate?

- HR = beats per minute (BPM)
- 1. count # of big boxes between QRS complexes
- 2. Divide 300 by that number

- Example: 300 / 4 boxes = 75 BPM (HR)

- If you want to be really accurate, do 1500 / # small boxes
  - 1500/20 = 75 BPM

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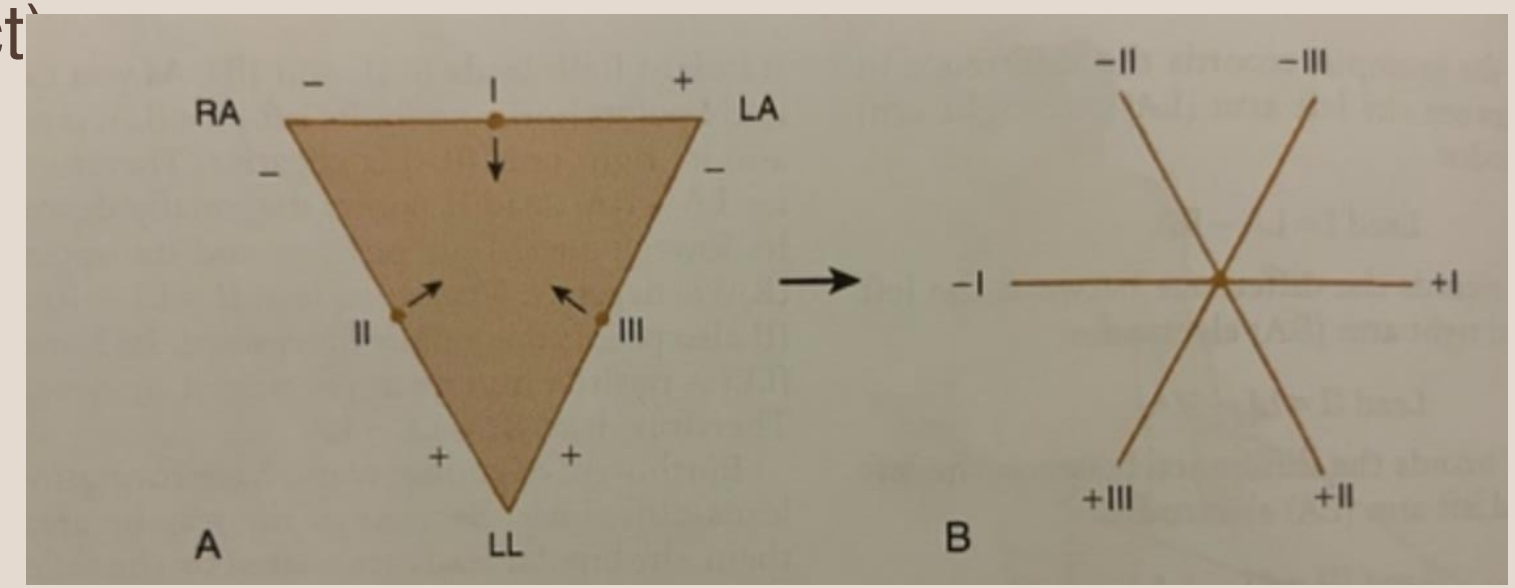
Standard Limb Leads I, II, III

Difference between two limbs

- Lead I: LA-RA this lead moved down (horizontal)
- Lead II: LL-RA this lead shifts right
- Lead III: LL-LA this lead shifts left (now they all intersect)



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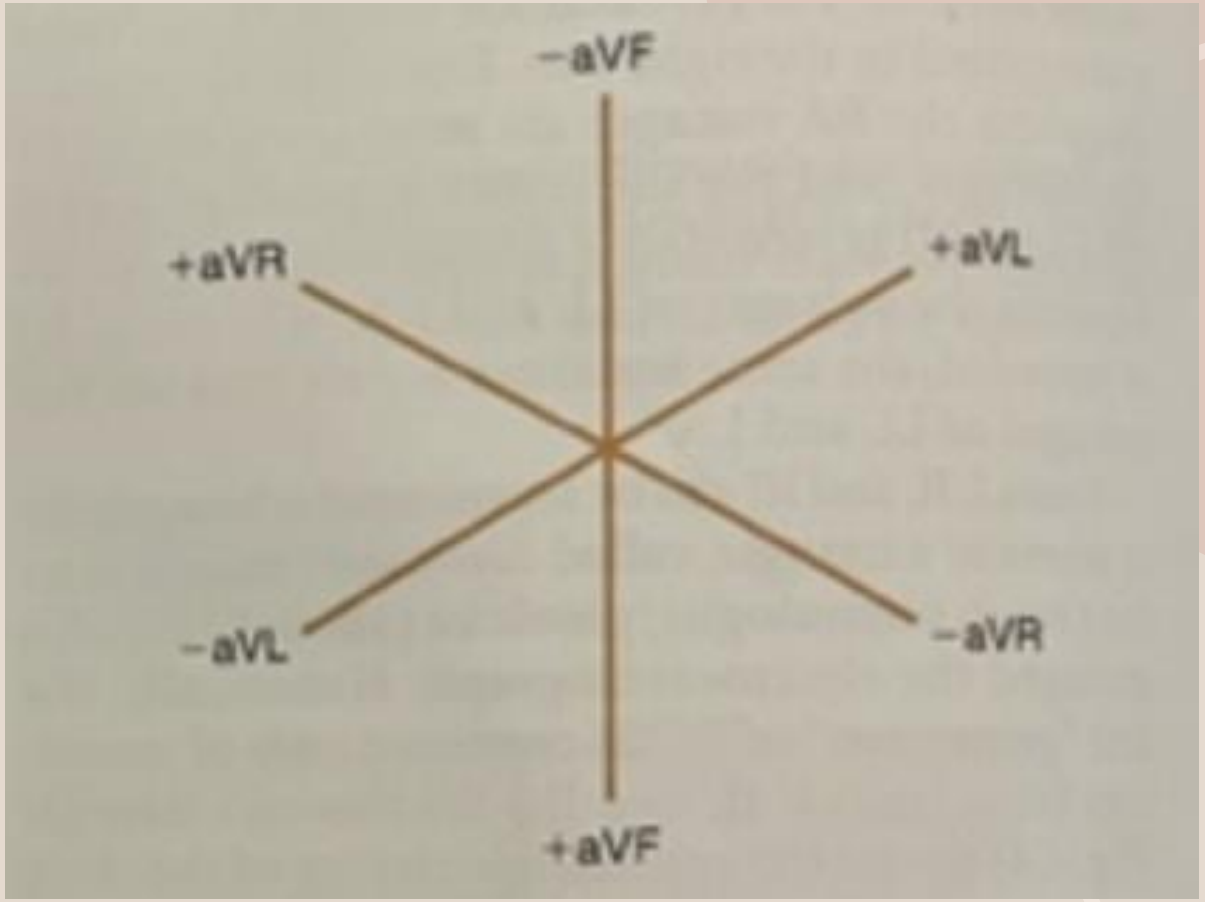
Augmented Limb leads: aVL, aVR, aVF

Electrical forces as recorded from one limb at a time

- a = augmented
- V = voltage
- L = left arm
- R = right arm
- F = left Foot



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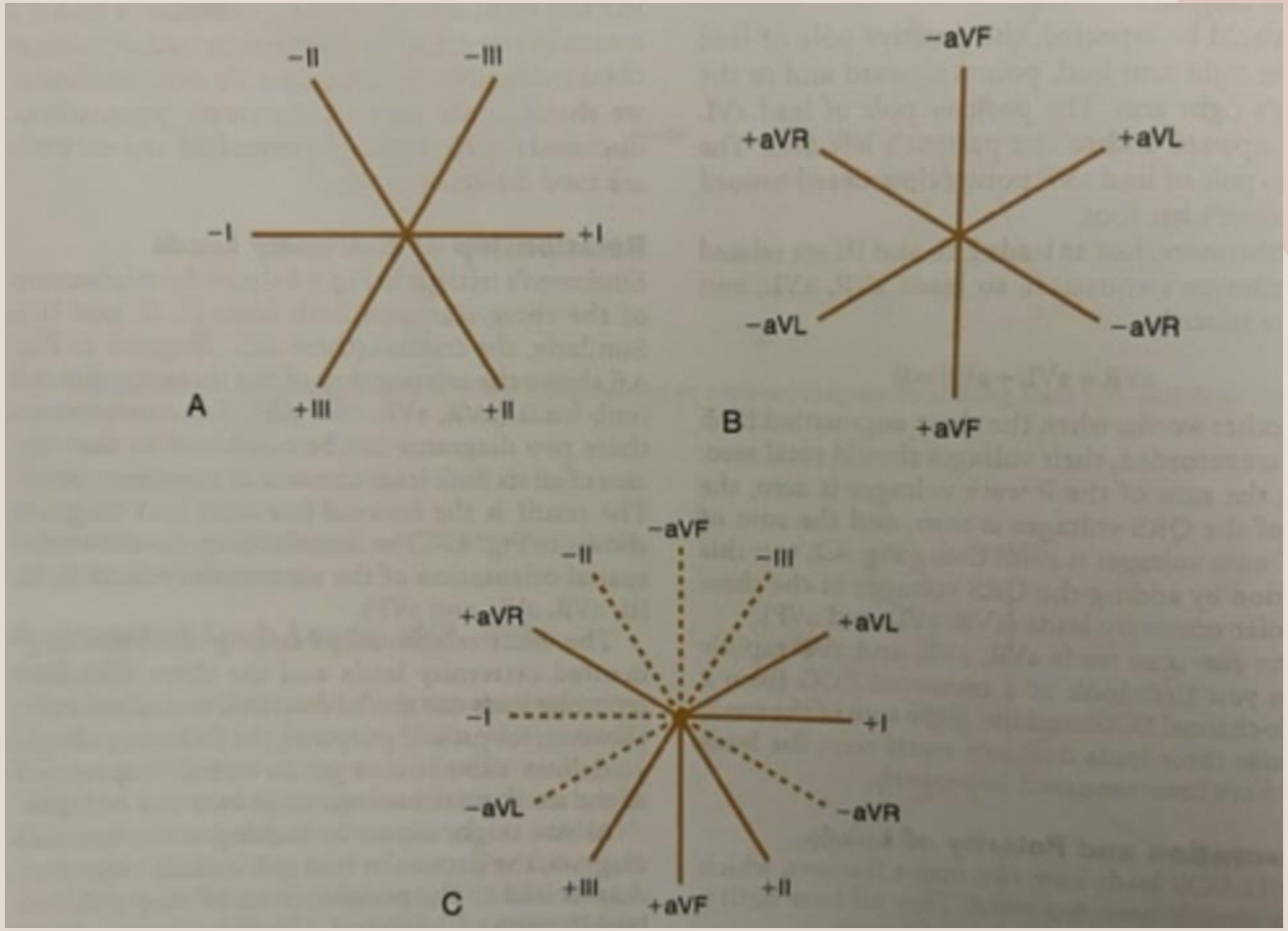
Putting it all together…



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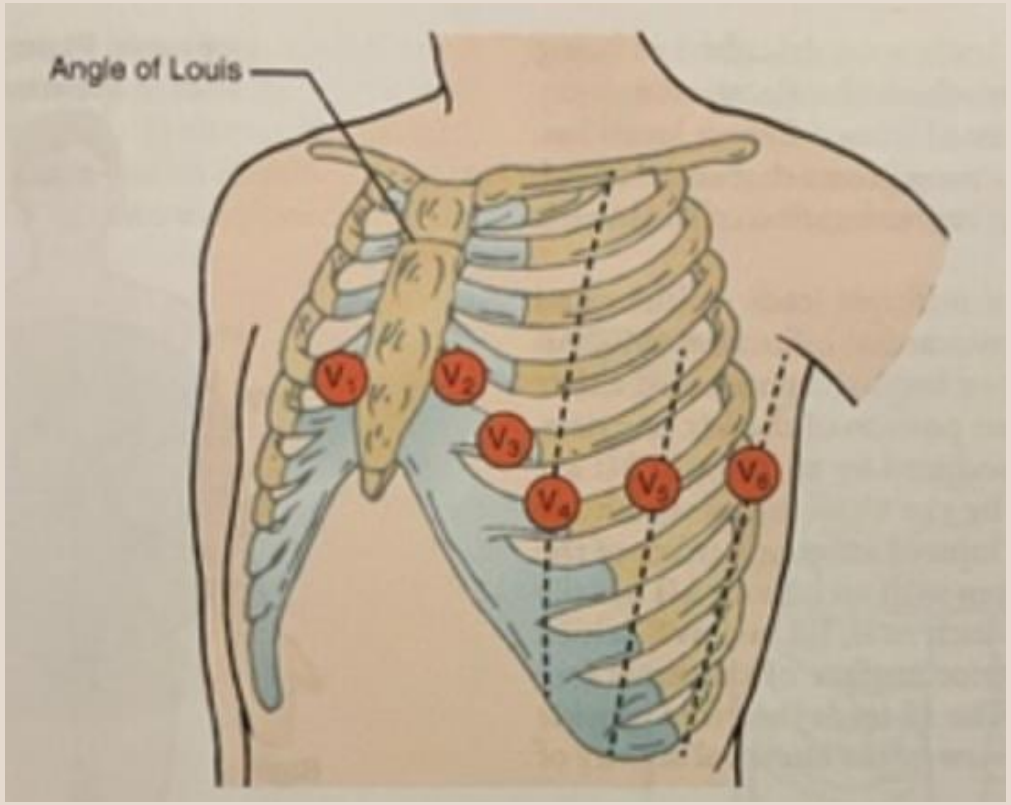
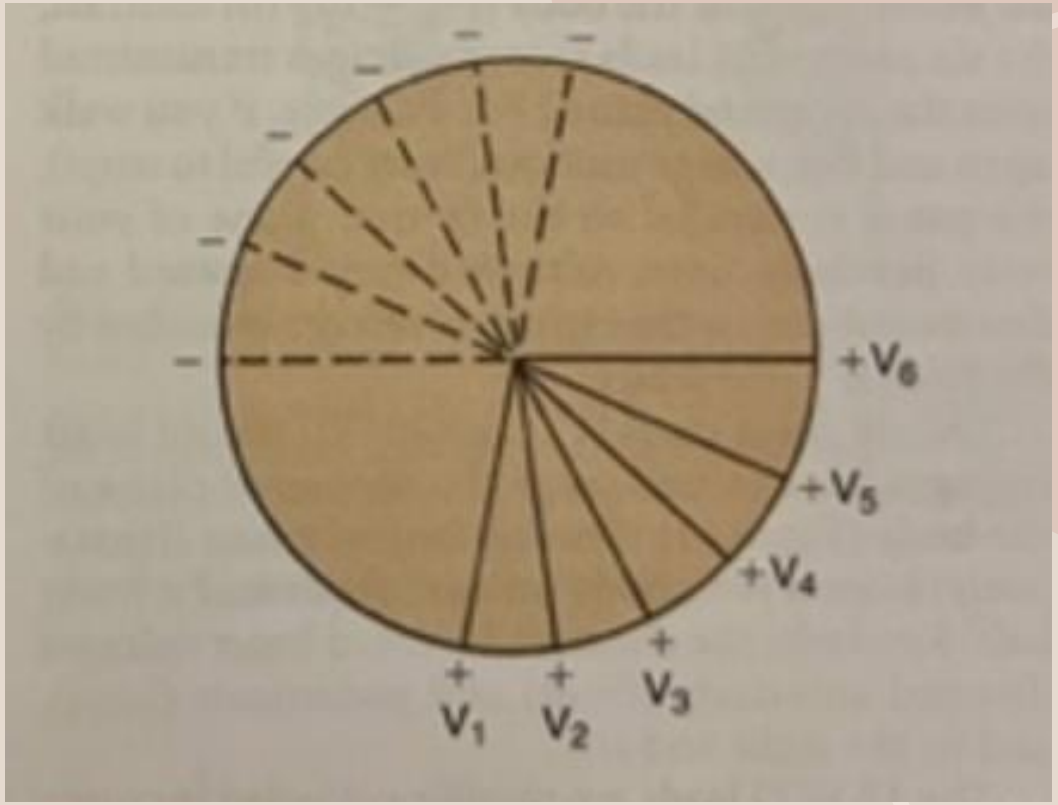
Precordial/Chest leads (V1-V6)





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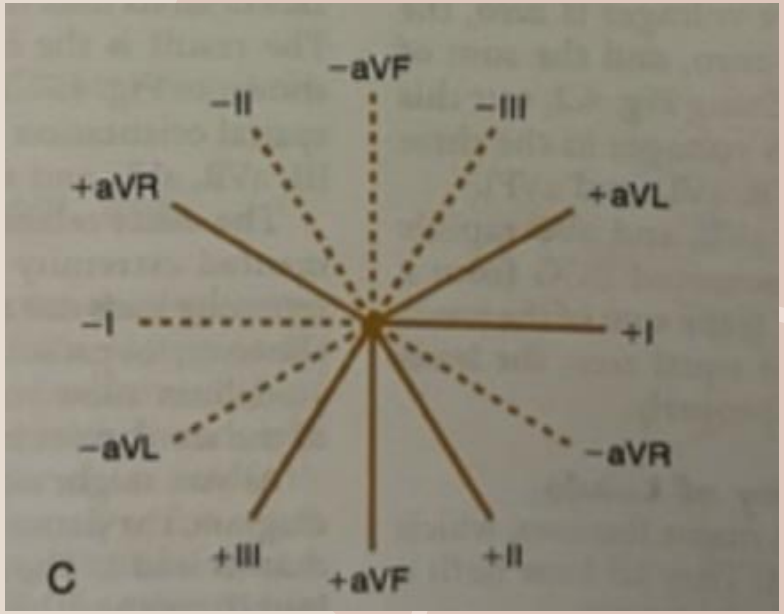
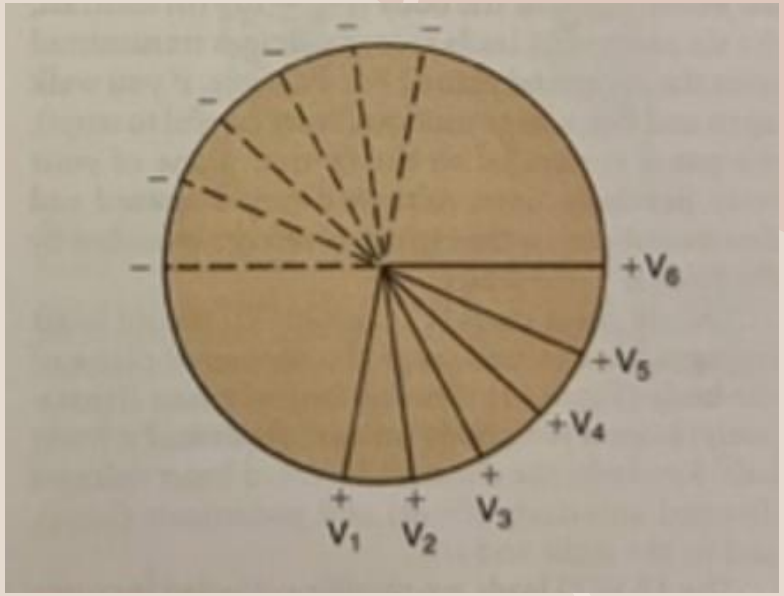
Combining all 12 leads…

Which area of the heart is seen through different leads?

- **Inferior**
  - downward direction toward feet
  - **Leads II, III, aVF**
- **Antero-septal**
  - ventricular septum and anterior wall
  - **Leads V1, V2**
- **Anterior**
  - anterior wall
  - **Leads V3, V4**
- **Lateral**
  - lateral wall
  - **Leads V5, V6**
  - **Leads I, aVL**





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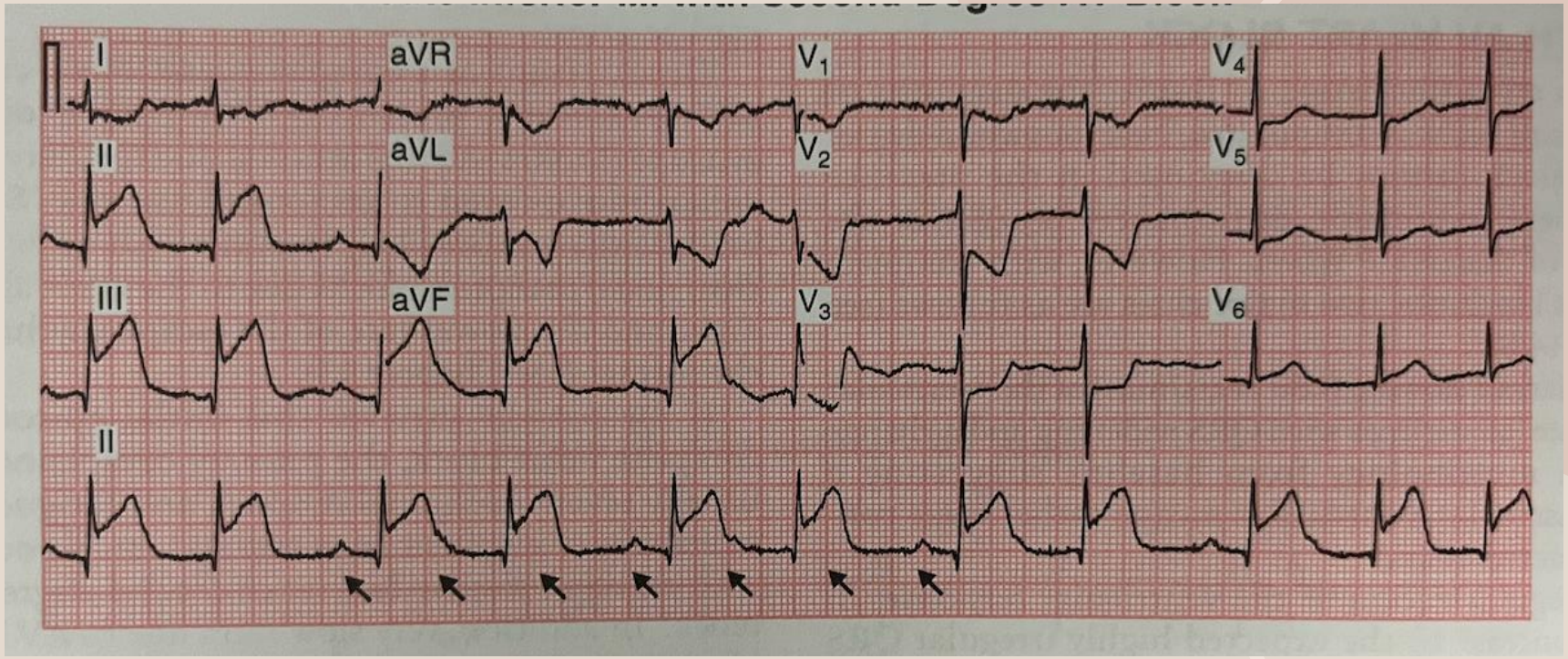
https://thephysiologist.org/study-materials/the-ecg-leads-polarity-and-einthovens-triangle

Example: INFERIOR MI

- **REMEMBER:**

- **Inferior**
  - downward direction toward feet
  - **Leads II, III, aVF**
- Where is the ST elevation?
  - **Leads II, III, aVF**



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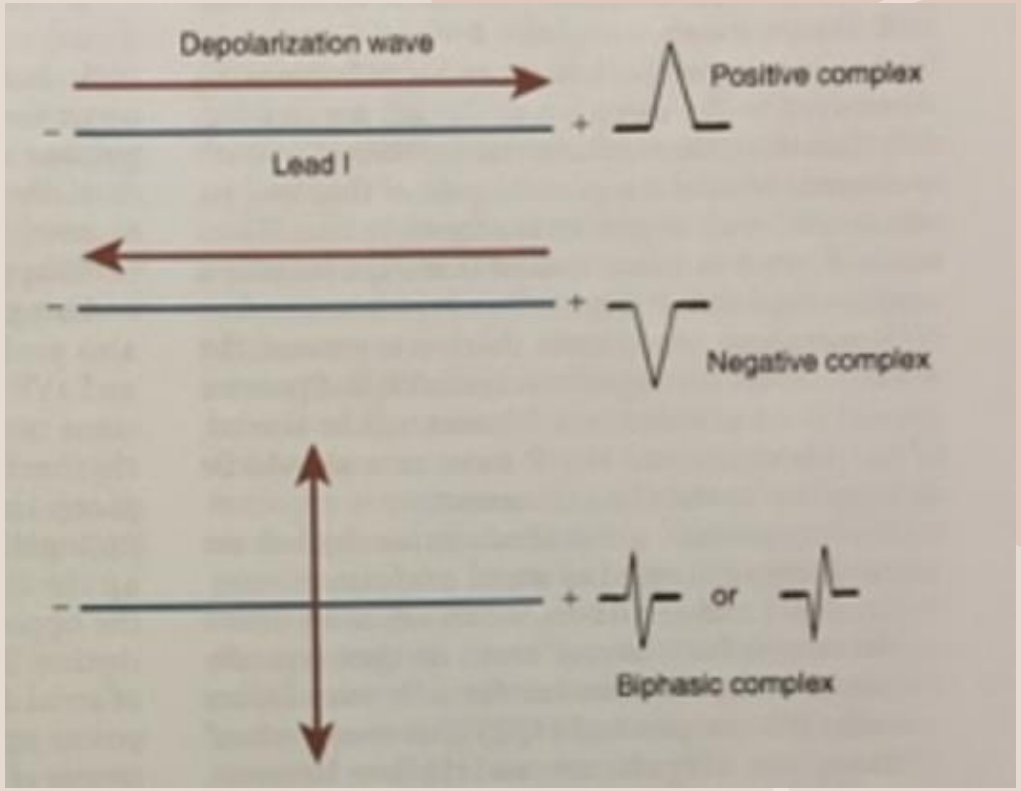
How to determine +/- complex:

- 1. Look at + and – of lead (ex: aVR or II)
- 2. Which way is depolarization occurring?
- 3. If it goes to the negative pole, negative waye
- 3b. If it goes to the positive pole, positive wave
  - Ex: aVR: depolarization goes + to – (so – p wave)
  - Ex: II: depolarization goes – to + (so + p wave)



Let's practice…

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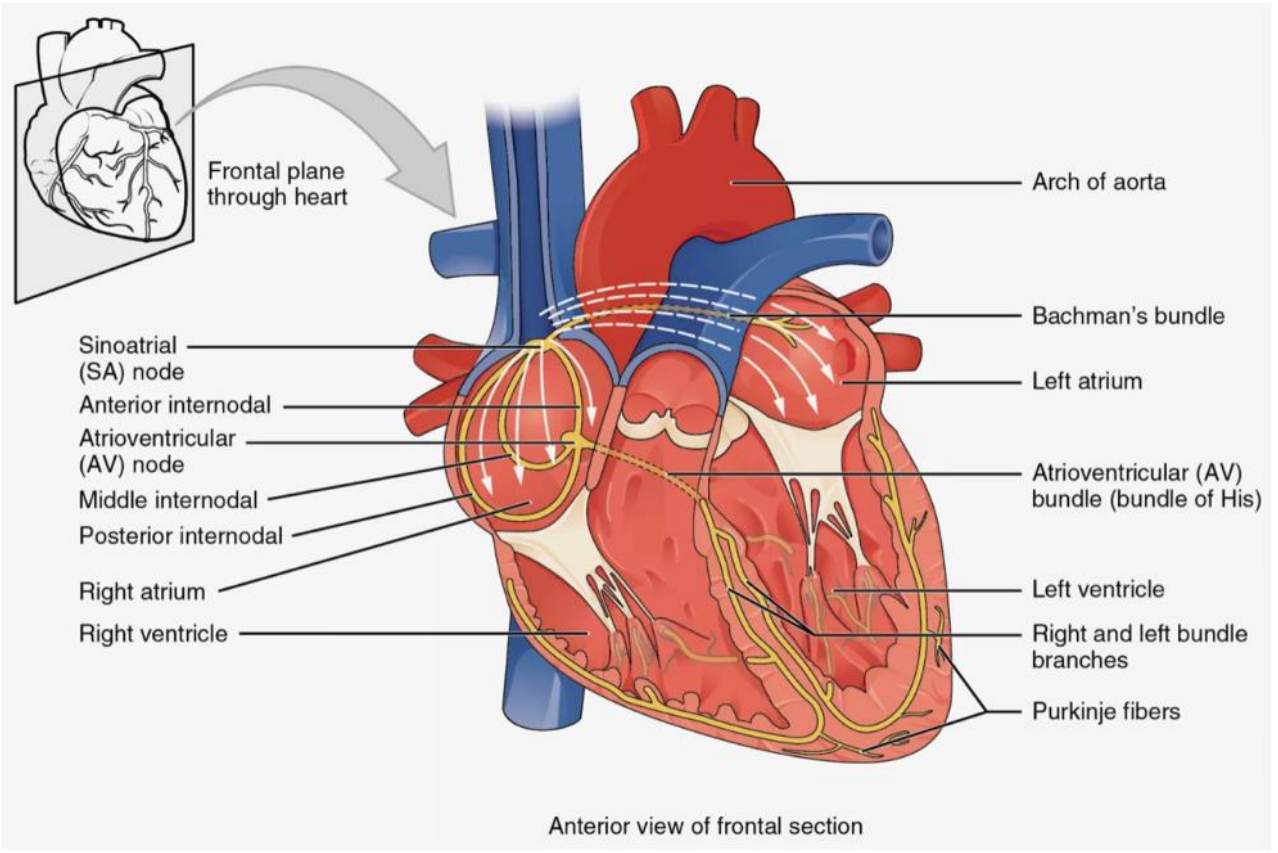
Think about a P wave…



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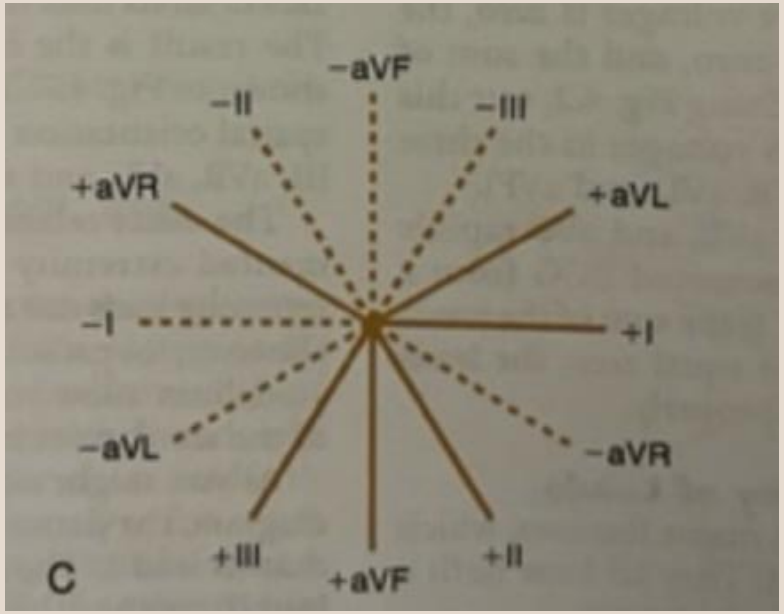

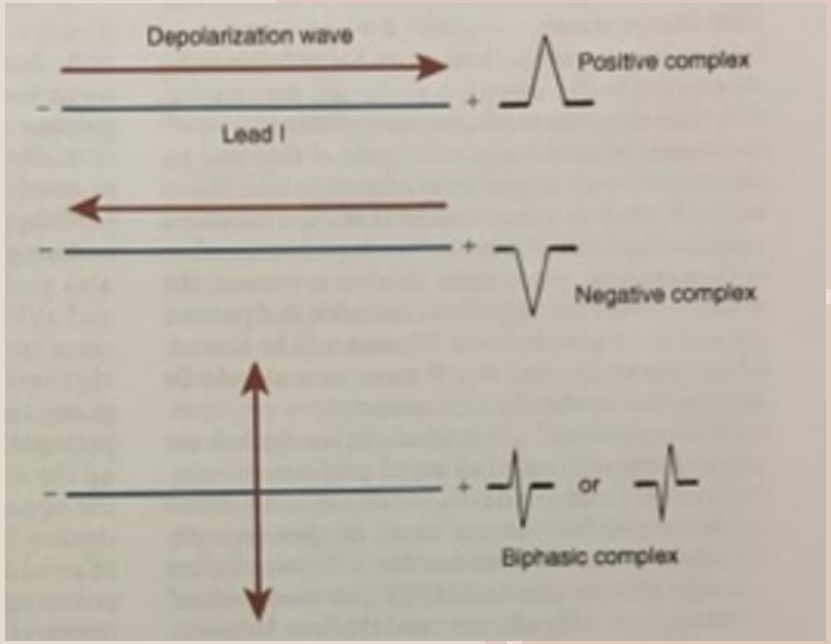

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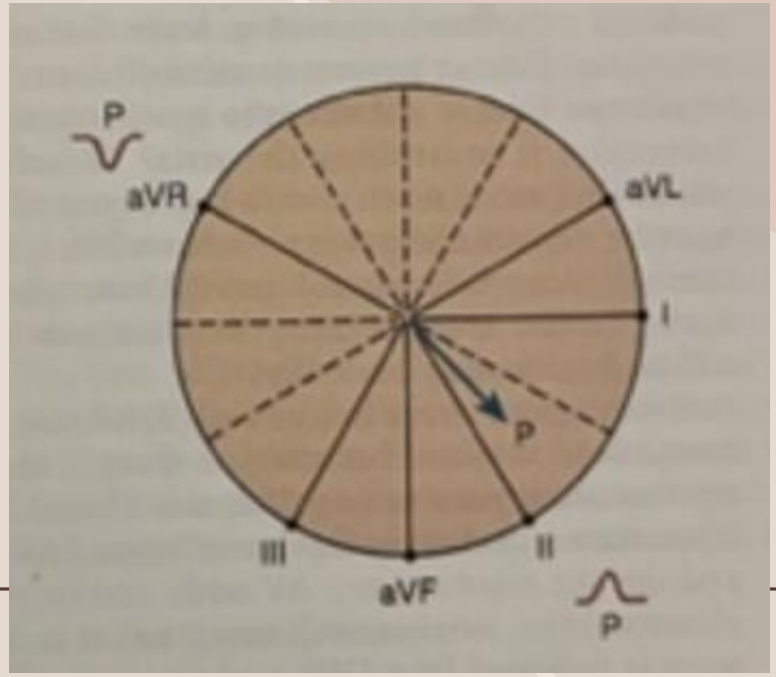

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Cardiac Axis

- Normal is 11 o'clock to 5 o'clock
- Look at leads I, II, III

Normal

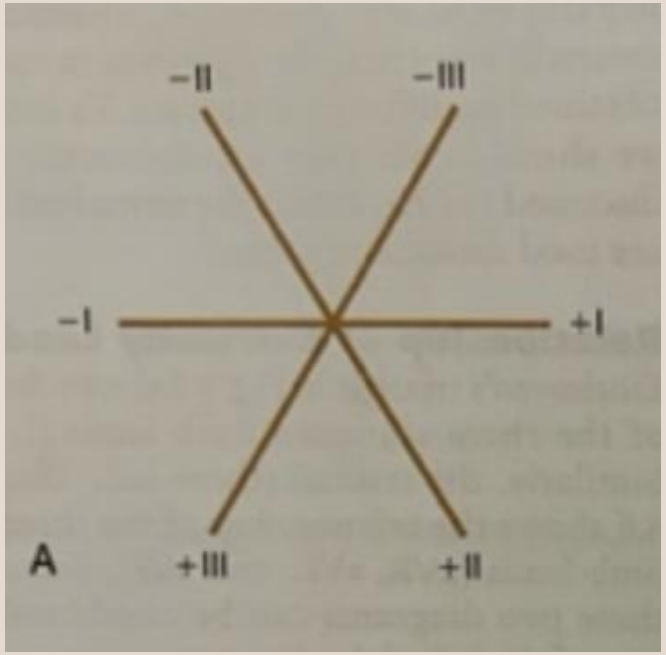
- Lead II most (+) deflection

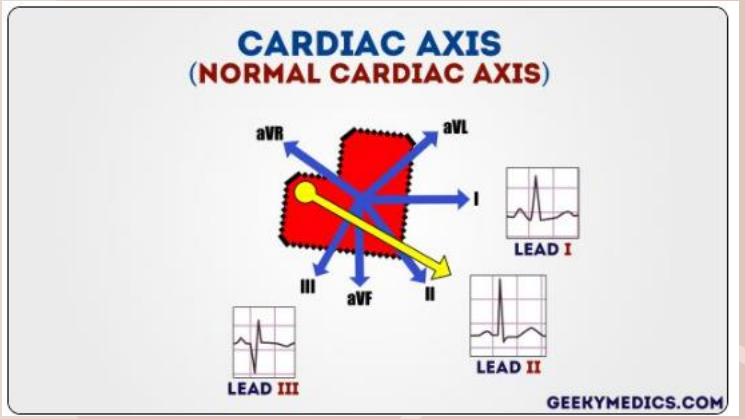
Left Axis Deviation

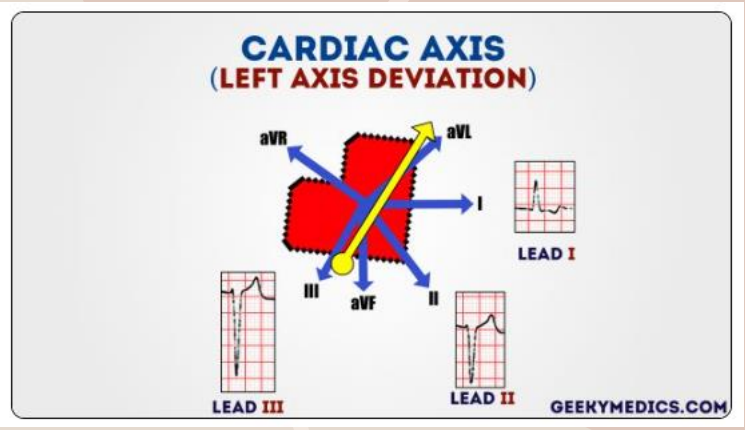
- Lead III most (+) deflection, Lead I (-)

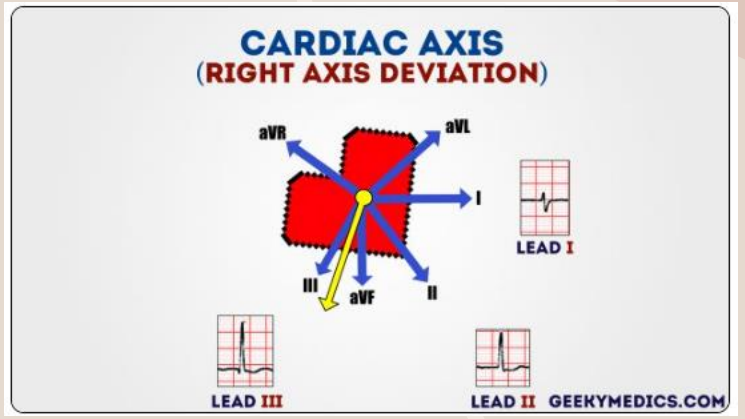
Right Axis Deviation

- Lead I most (+) deflection, Lead II and III (-)









https://geekymedics.com/how-to-read-an-ecg/

Things to consider to assess ECG…

- Is the Heart Rate normal or abnormal?
- Is the Heart Rhythm regular or irregular?
  - Regularly irregular (pattern of irregularity) or irregularly irregular?
- Cardiac axis?
- Are there P waves? (Does a QRS follow?) Are they normal?
- Is the PR interval normal?
- Is the QRS wide (>0.12 sec) or narrow (<0.12 sec)?
  - If a multiple Q waves (thinking prior MI), check if >25% of R wave that follows or > 2mm in height and >40 ms width
- Is the ST segment elevated or depressed?
- Are the T waves tall or inverted?

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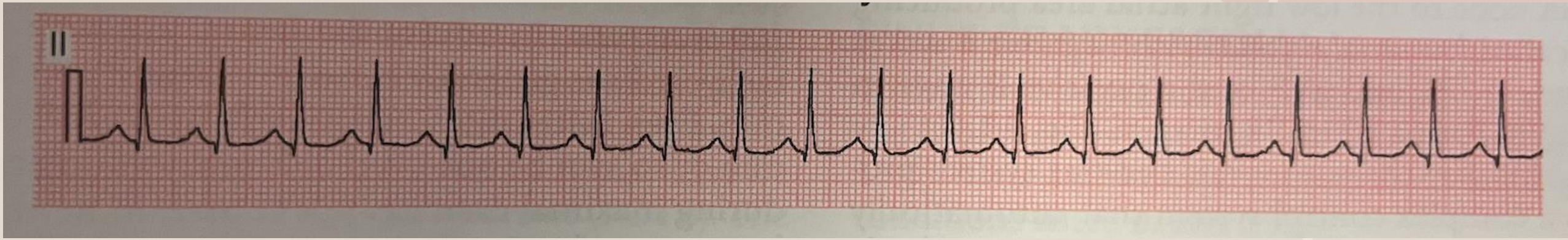
Normal Sinus Rhythm

- Average heart rate: 60-100 bpm

https://infogram.com/normal-sinus-rhythm

Sinus Tachycardia

- Sinus rhythm but
  - **Heart rate > 100 bpm**



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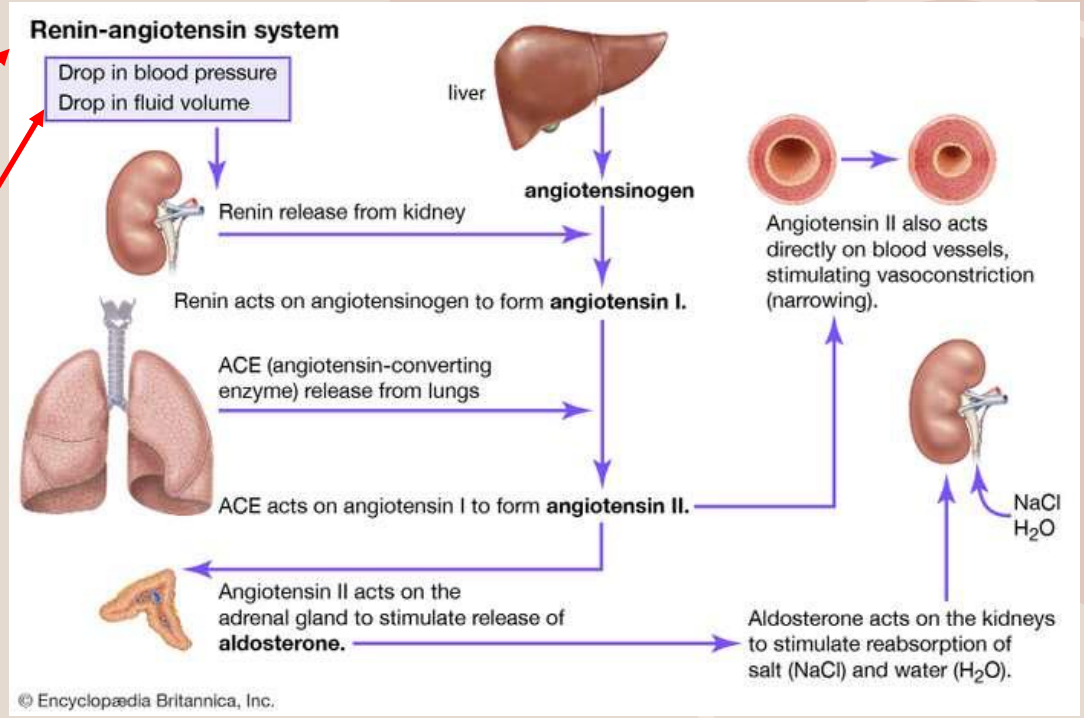
How does this tie in to physiology?

- **Tachycardia**
  - **Is a r**esults of activation of **neurohormonal system**
    - (sympathetic nervous system stimulation)
  - and release of norepinephrine
  - and **activation of renin-angiotensin aldosterone system**

(this is how kidneys regulate the blood pressure…they see drops in blood pressure in the body and activate the RAA system…they hold on to salt and water)



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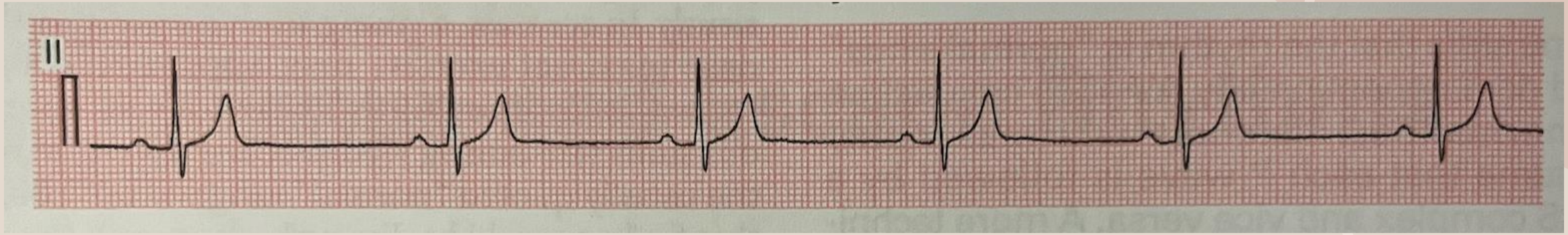
Sinus Bradycardia

- Sinus rhythm but
  - **Resting heart rate of < 60 bpm**
  - (or < normal range based on child's age)



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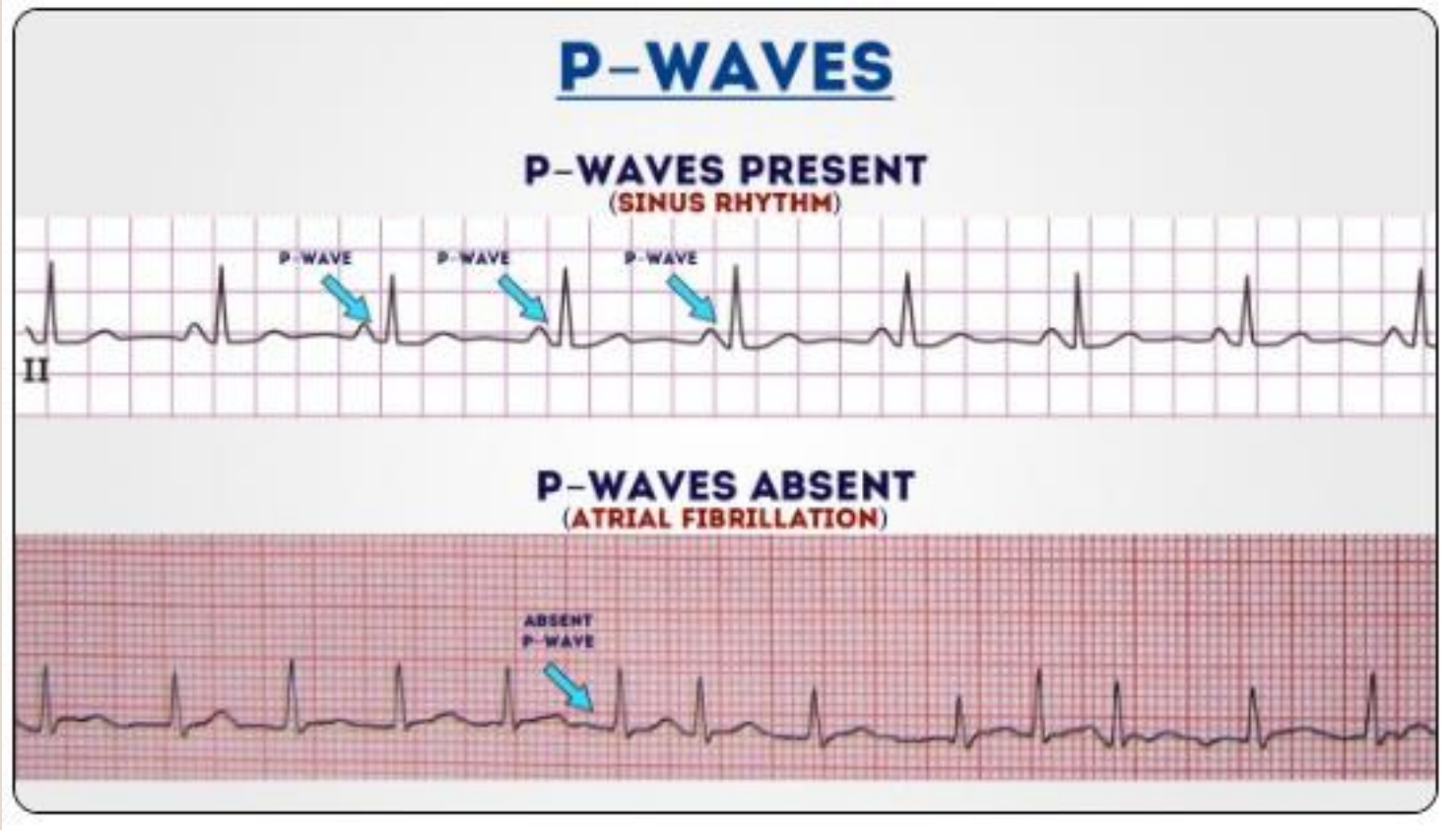
Atrial Fibrillation

- Irregularly irregular rhythm
- NO P WAVES
- Narrow QRS complex
- Causes:
  - “holiday heart”/EtOH abuse
  - Cardiac surgery
  - Cardiomyopathy
  - Hypertension
  - Hyperthyroidism
  - Valvular disease
  - WPW
  - Much more
- Treatment: CCB or BB
- Anticoagulation: consider CHA2DS2-VASc to assess risk



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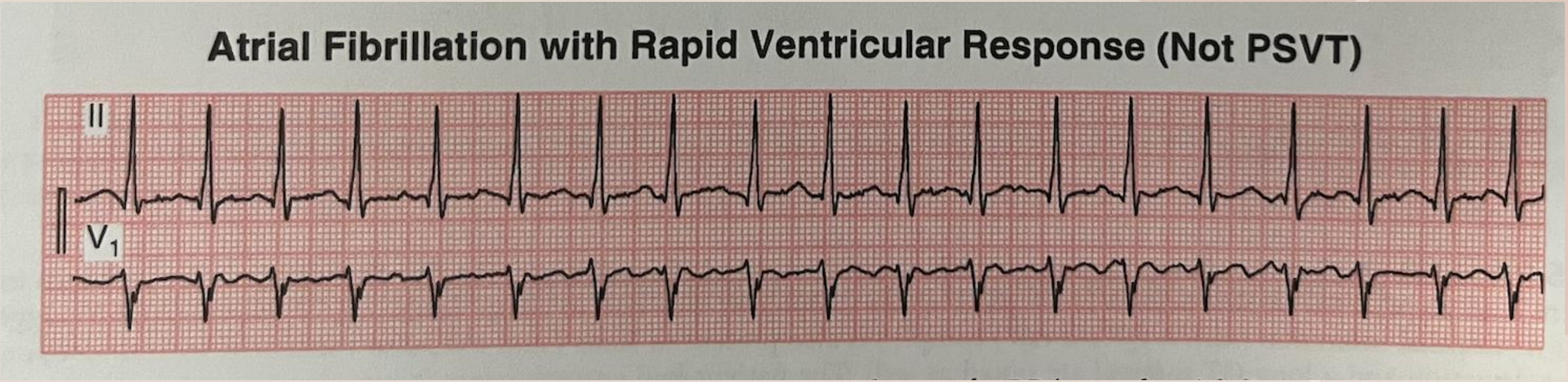
Atrial Fibrillation



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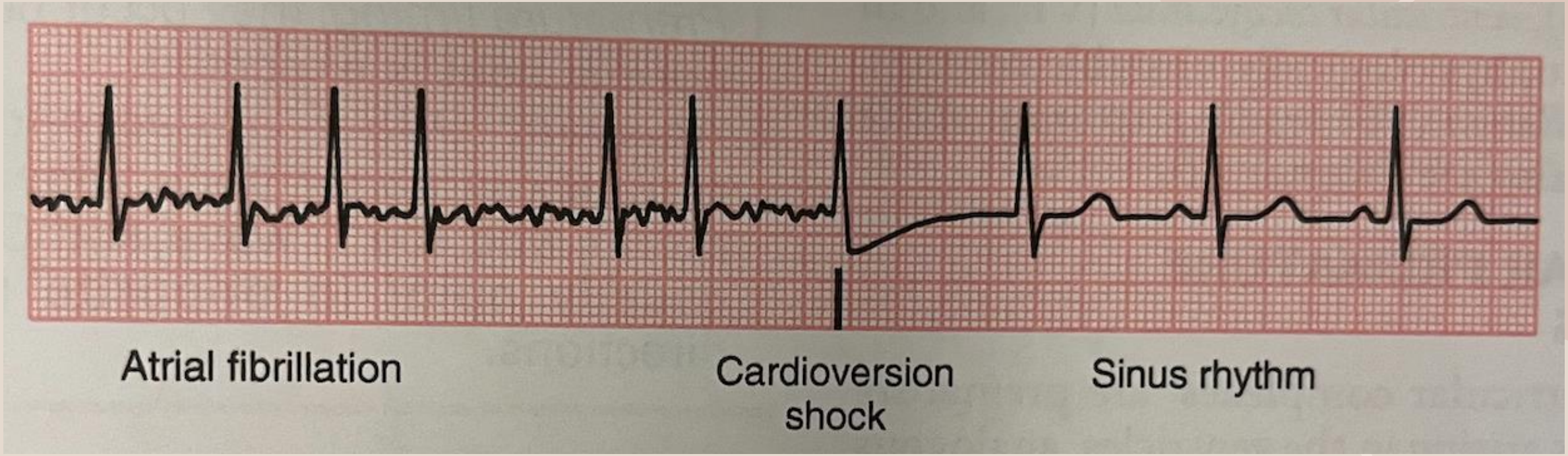

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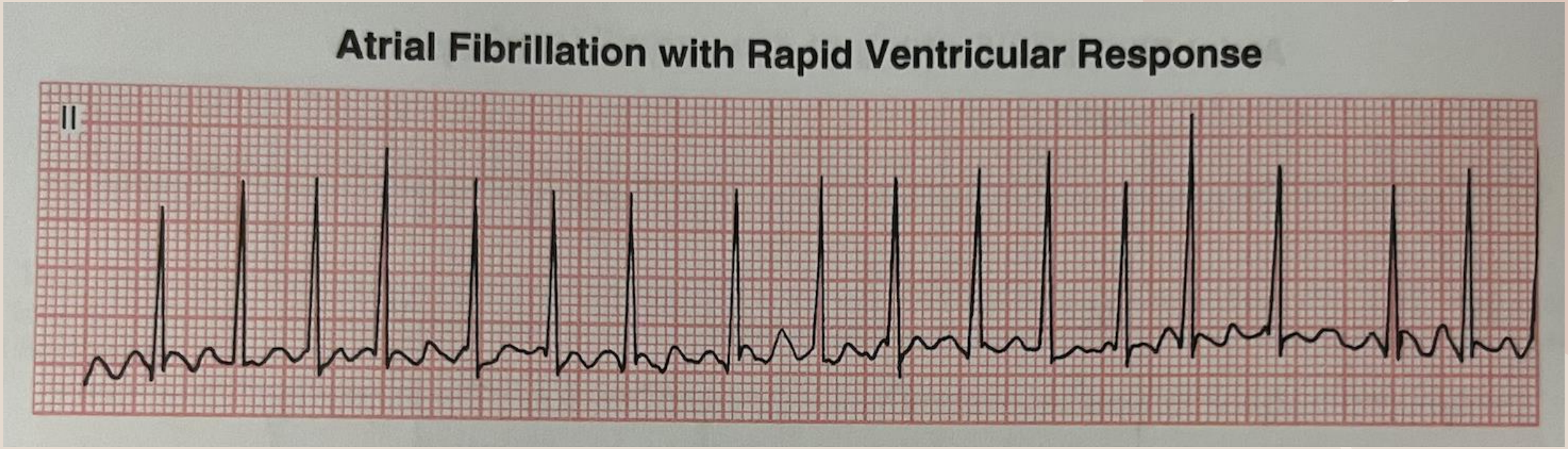

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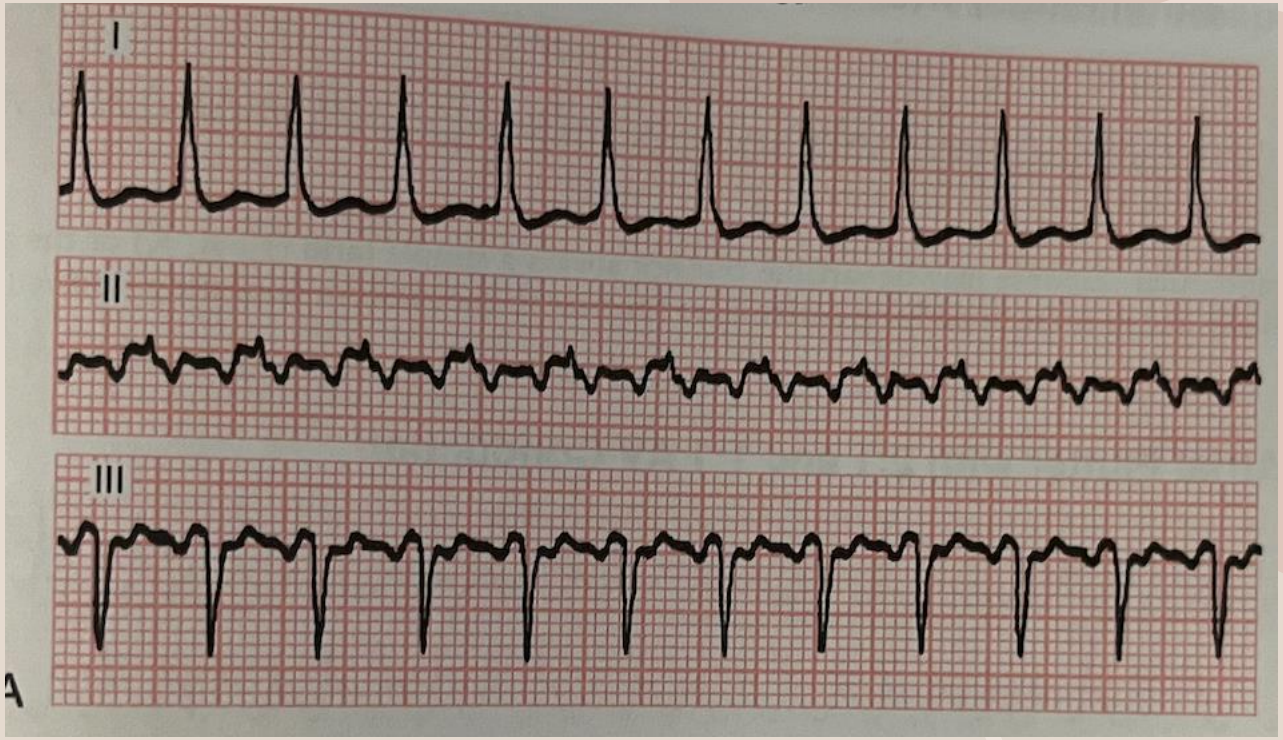
Atrial Flutter

- **Irregularly irregular rhythm**
- **NO P WAVES**
- Narrow QRS complex
- Regular, **sawtooth pattern**



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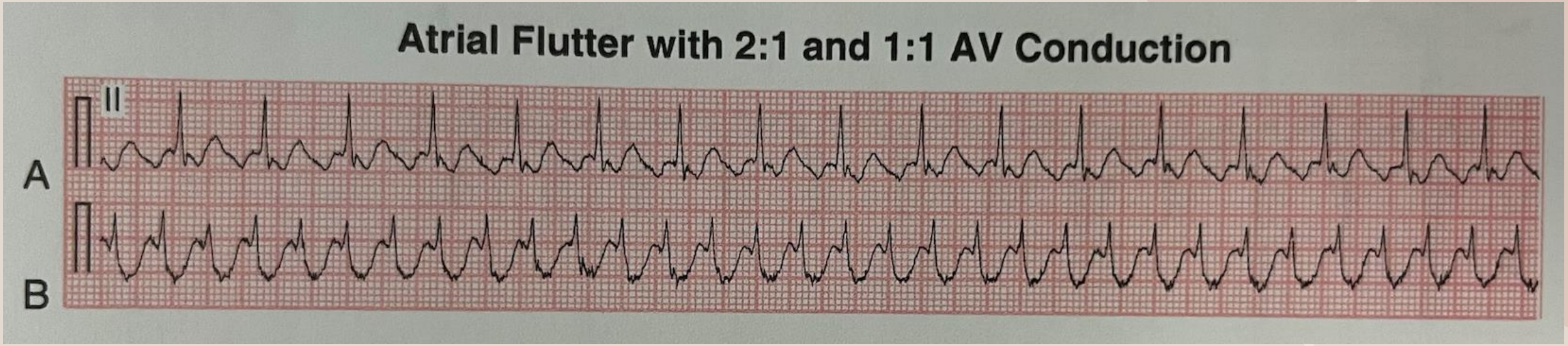

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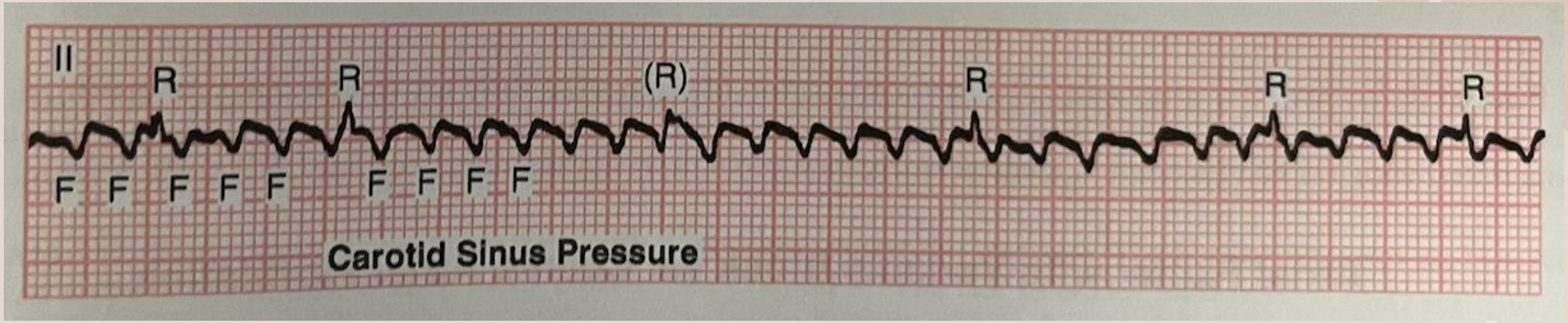
Atrial Flutter

- This shows carotid sinus massage
- Carotid sinus massage will slow the ventricular rate



https://smartypance.com/lessons/conduction-disorders/
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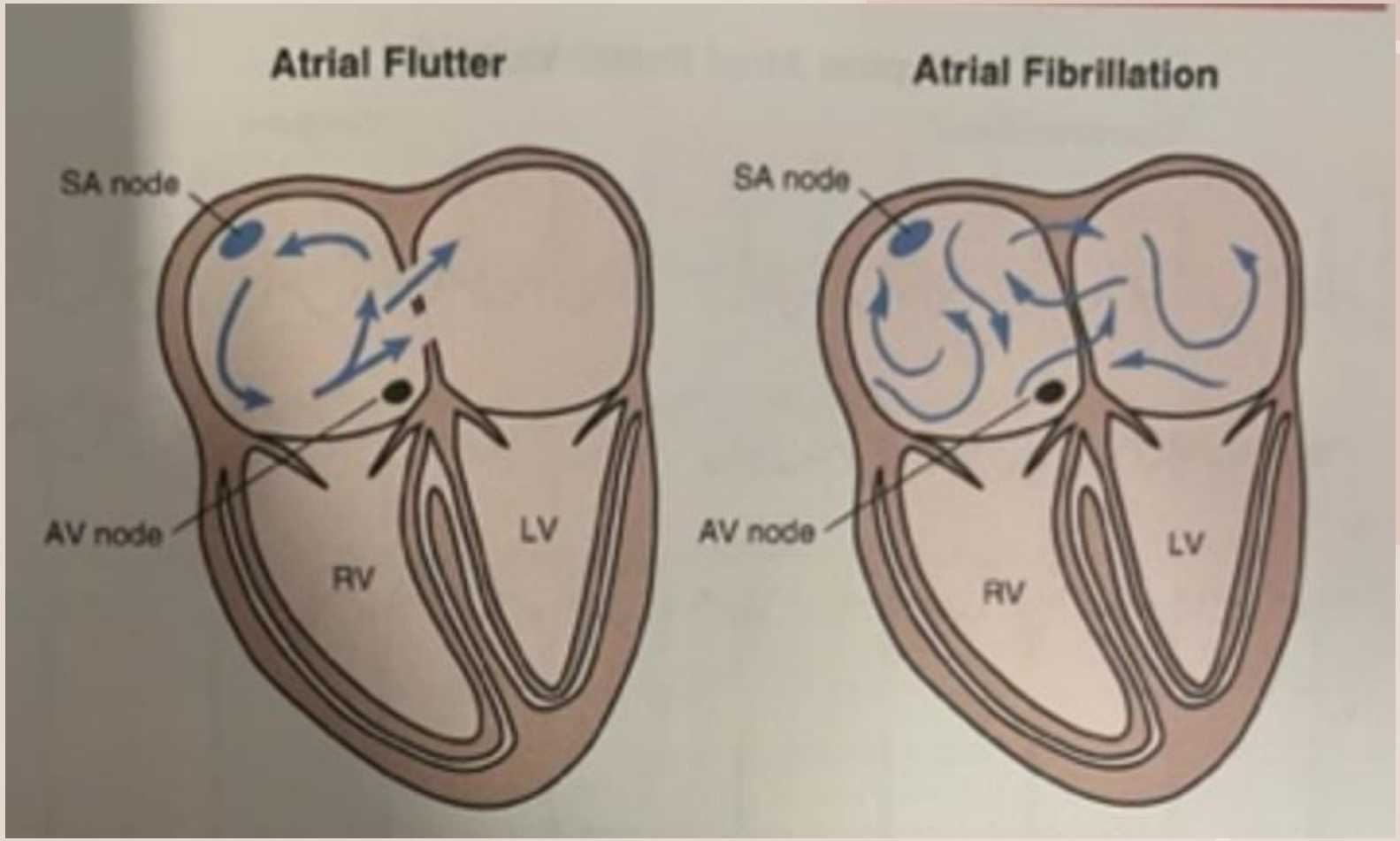
AFib vs. AFlutter

- Aflutter frequently PAC initiated due to large reentrant wave
- (usually) counterclockwise
- Afib frequentlyfrom abnormal impulses from Pulm veins in LA causing multiple reentrant waves



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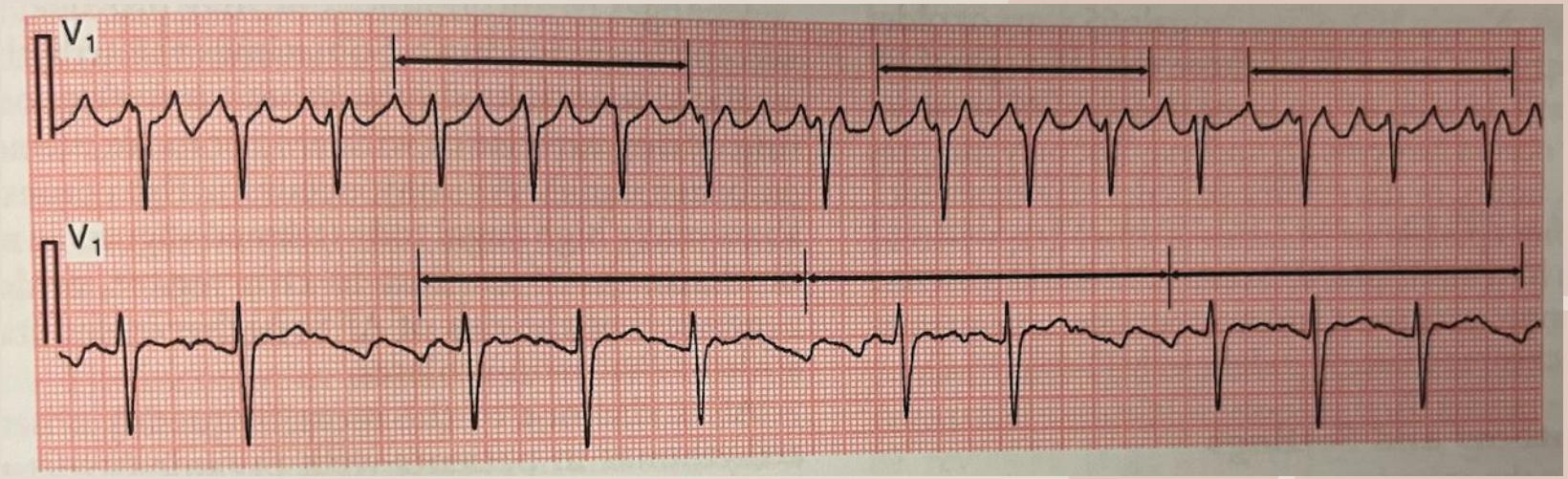
AFib vs. AFlutter



- Get your calipers! (or use anything to measure)
- Top panel is Afib, bottom panel is Aflutter
  - In Afib, atrial waves (these are NOT p waves) have different timing and shape
  - In Aflutter, atrial waves have the SAME timing and SAME shape
- With calipers, you can see in the bottom image that if you choose the peak of an atrial wave, that equal caliper spacing lands at the SAME area on the wave as you march along
  - This is NOT true as evidenced in the atrial fibrillation example at the top

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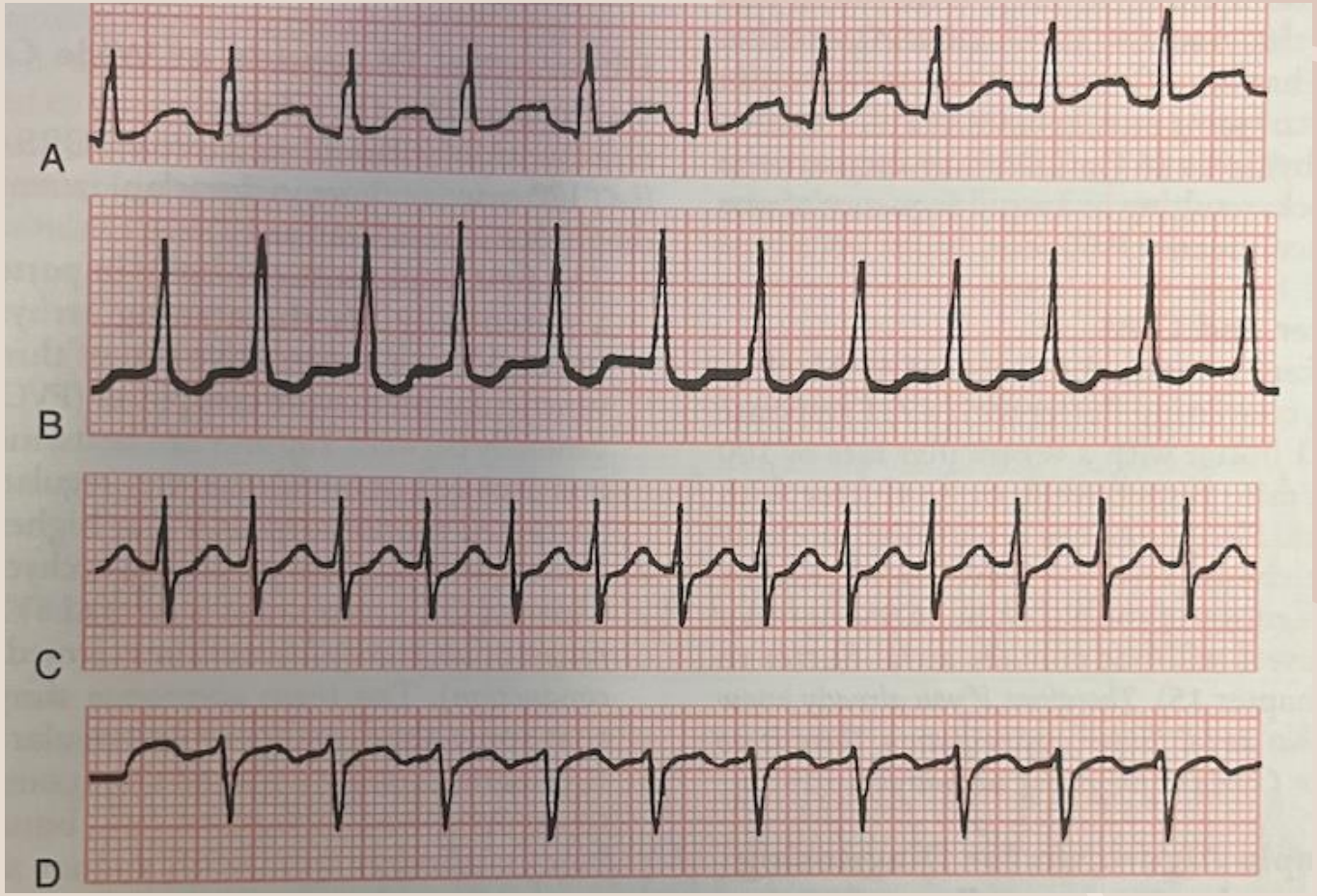
Tips to tell apart…

- TIP:
  - Sinus tachycardia
  - Atrial fibrillation
  - Paroxysmal supraventricular tachycardia
  - Atrial flutter
- May all look similar if only looking at one lead
- Check all the leads!



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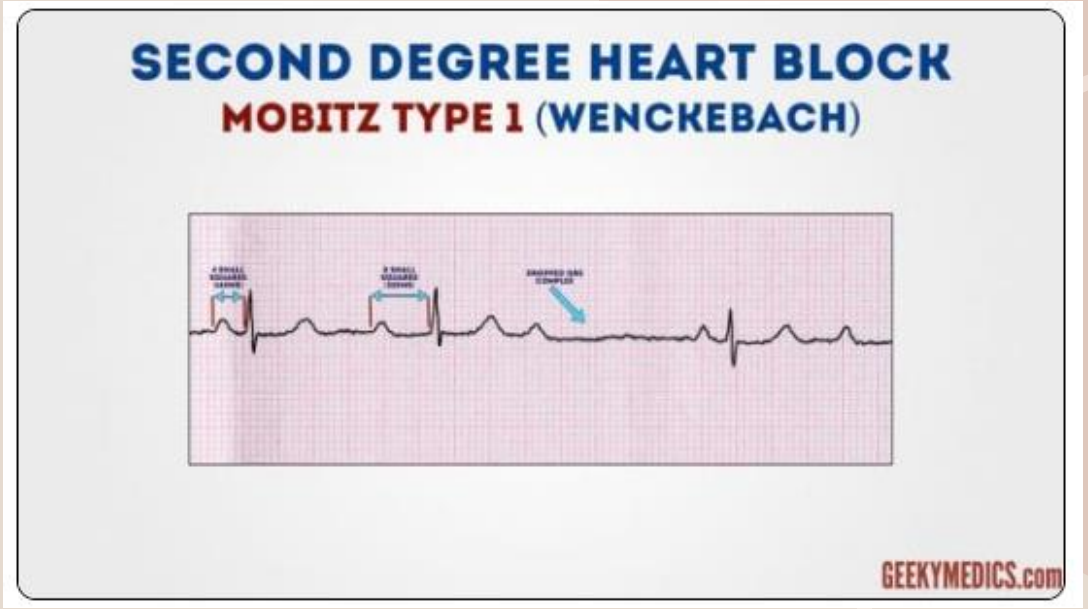
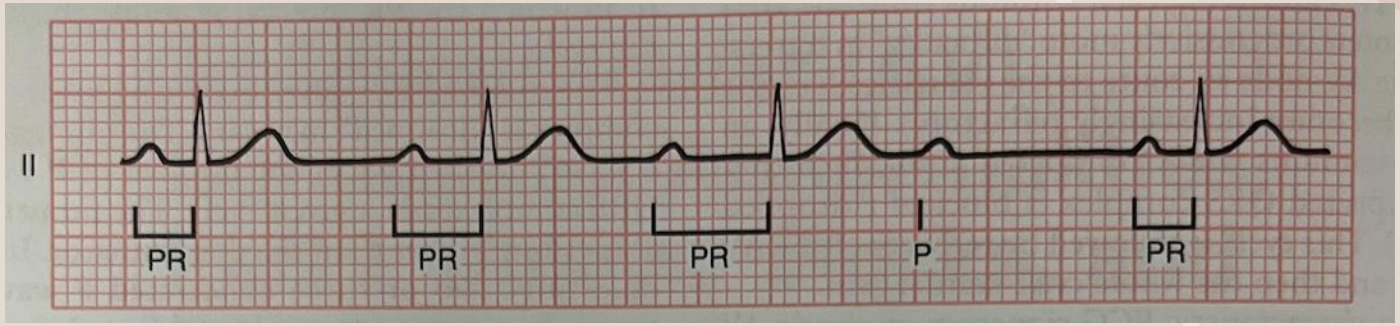
2nd Degree AV Block: Type I

- Type I Second Degree
- “Wenckebach”
- Sinus rhythm
- Each PR gets longer, then a QRS is missed
- “longer longer longer drop…”





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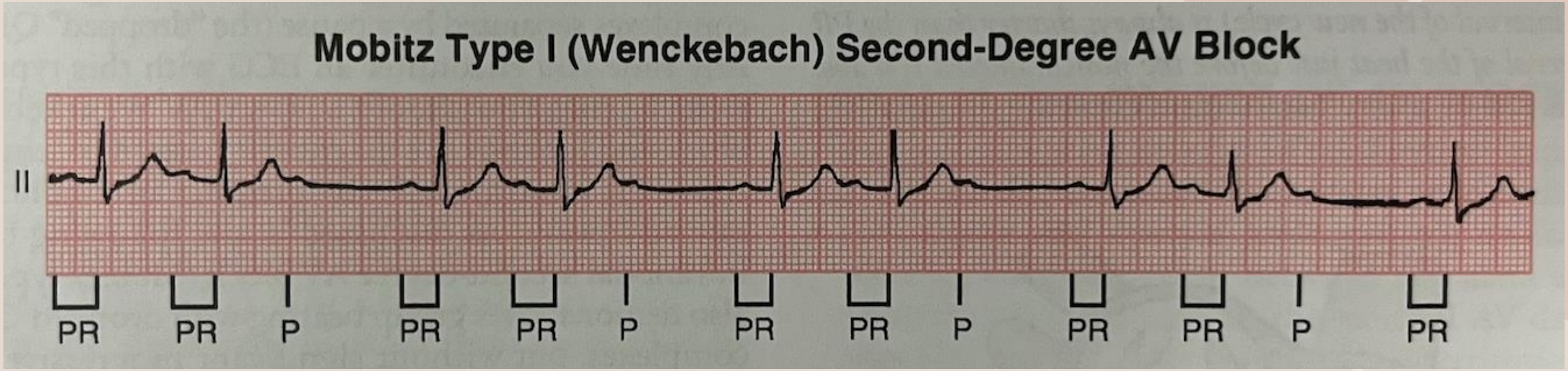
2nd Degree AV Block: Type I



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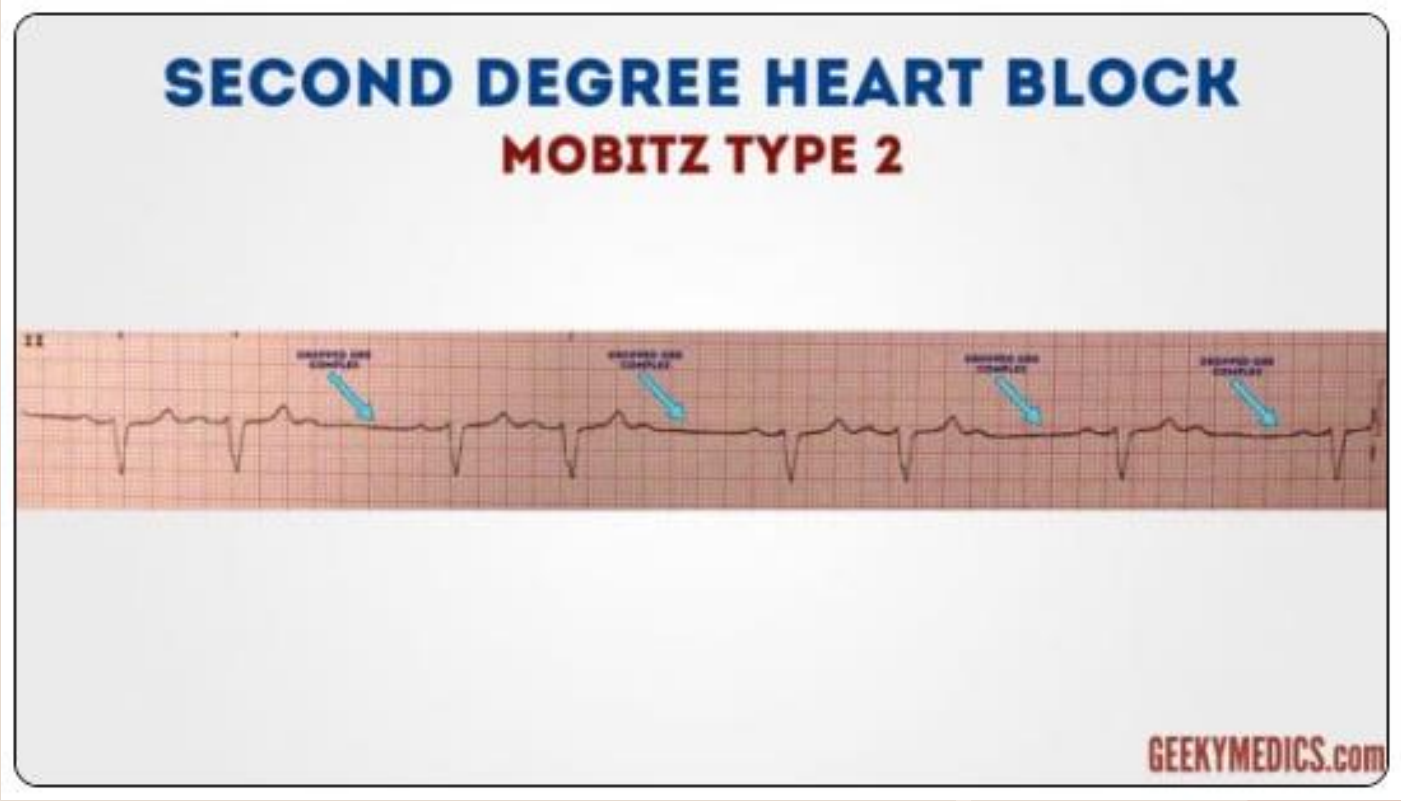
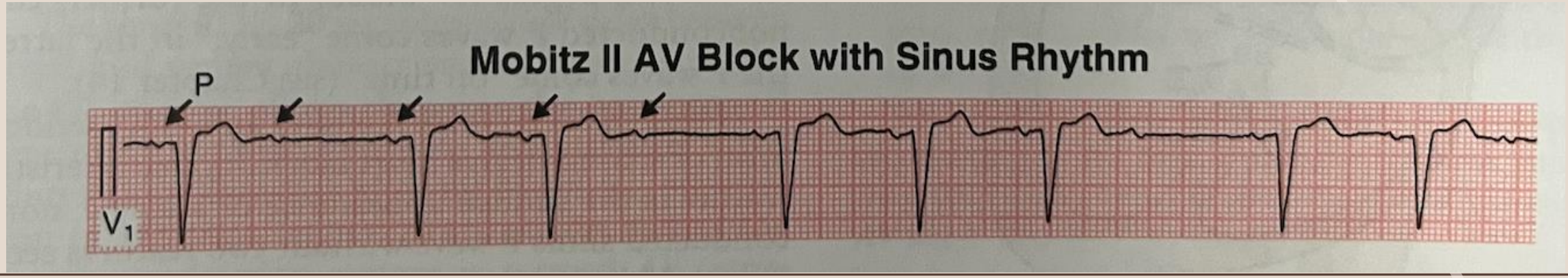
2nd Degree AV Block: Type II

- Type II Second Degree
- “Mobitz”
- **PR interval is FIXED**
- occasional dropped QRS complexes
- **“some get dropped some get through now you’ve got Mobitz 2”**





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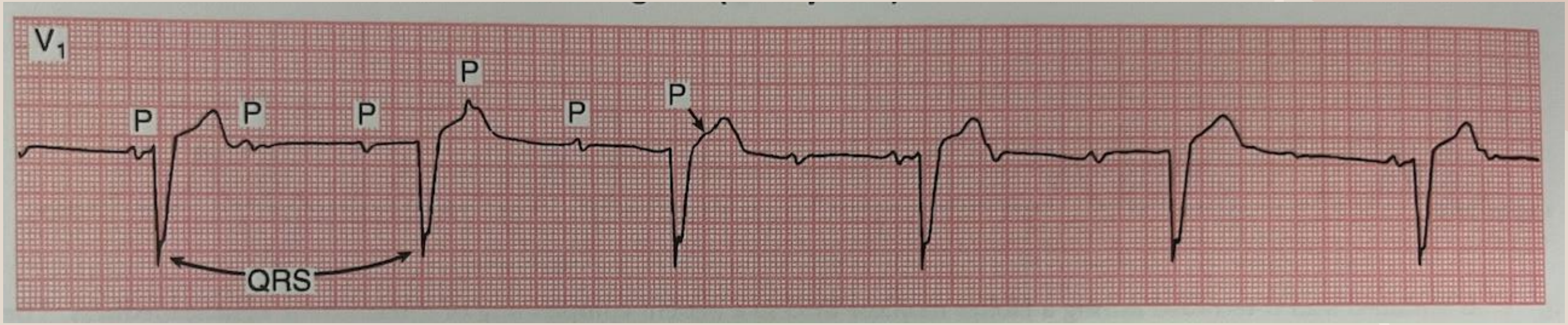
3rd Degree AV Block

- No association between the P wave and QRS
- ”beat to the beat of your own drummer”
- P’s marching along but unrelated to QRS



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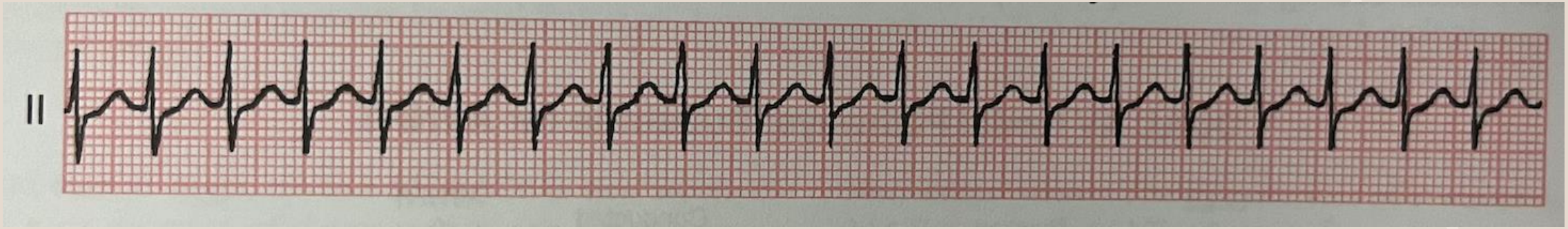
Paroxysmal Supraventricular Tachycardia

- Narrow complex tachycardia
- Starts above the ventricles
- Usually quick onset and termination (may have no sxs), usually due to reentry
- SVT starts the same and stays the same rate (sinus tachy may change)



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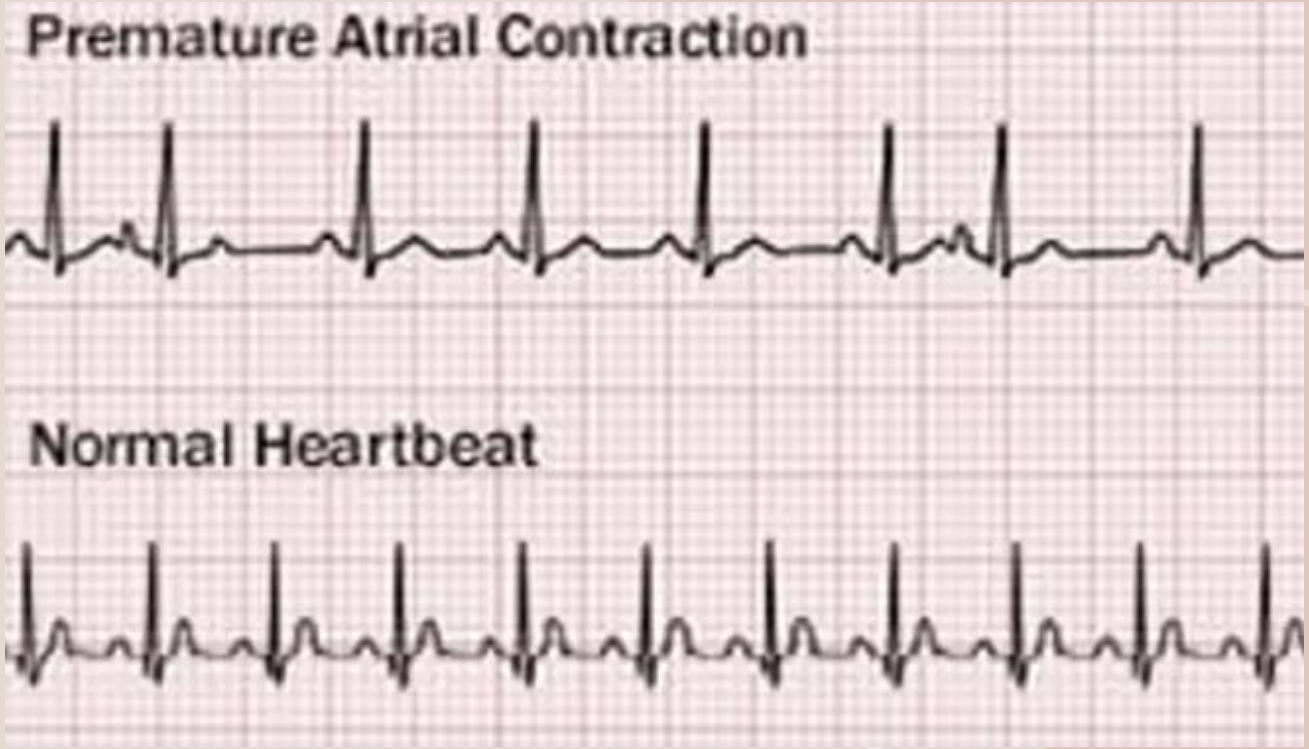
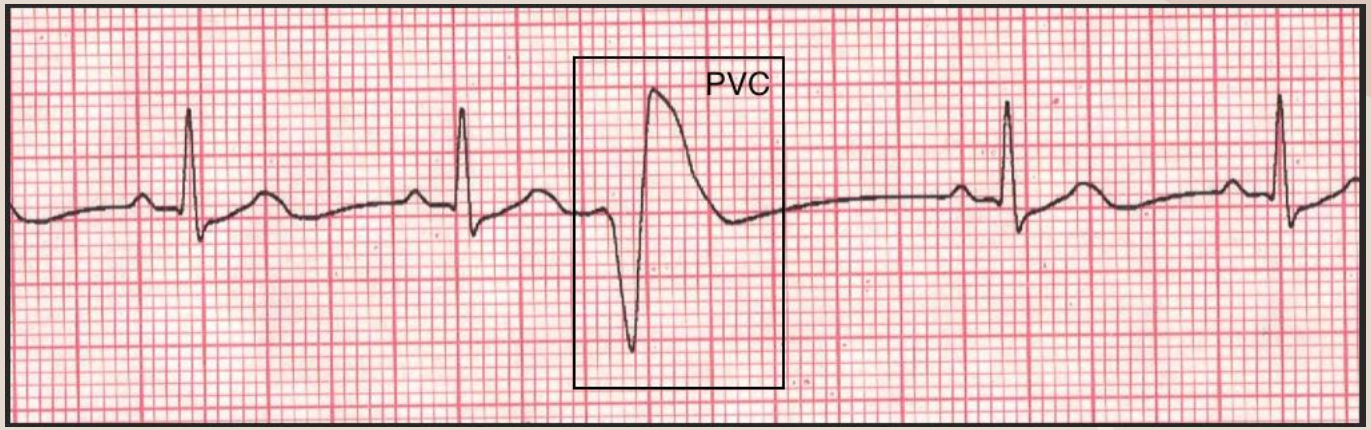
Premature Beats (PAC, PVC)

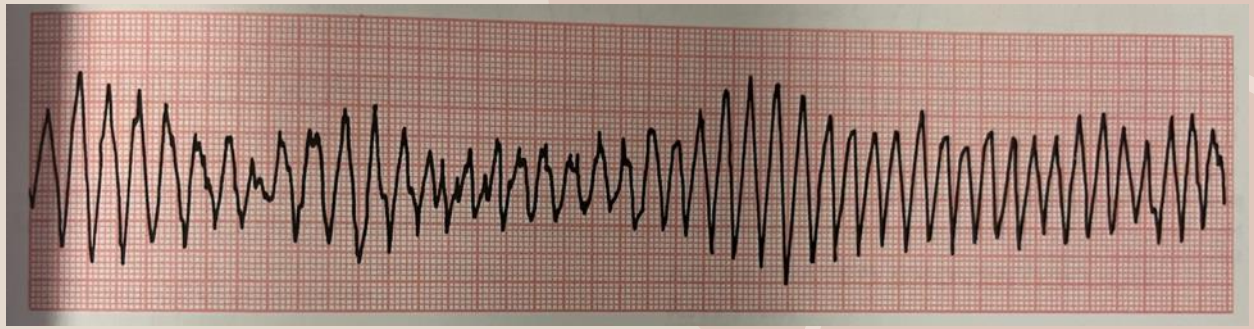
- PAC:
  - unusually shaped P wave
- PVC:
  - Early
  - Wide
  - Weird looking QRS
  - NO P WAVE



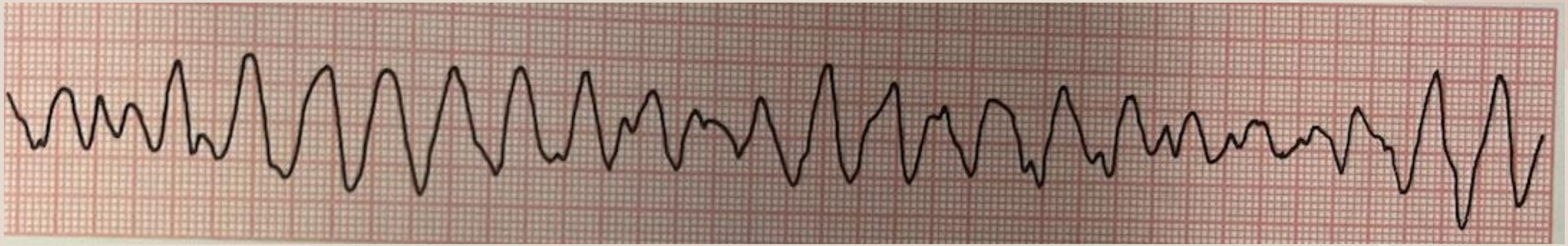


Premature Atrial Contractions: Causes, Symptoms, Diagnosis, Treatment (webmd.com)
http://mylifeasaparamedicstudent.blogspot.com/2012/11/pac-pvc-pjc.html

Torsades de Pointes



- Polymorphic ventricular tachycardia
- French for “twisting of points”
- “twisting” around a line
- Can devolve into Vfib
- Can be causes by long QT or medications/drugs
- Treatments: magnesium, BB (propranolol), pacemaker/defibrillator



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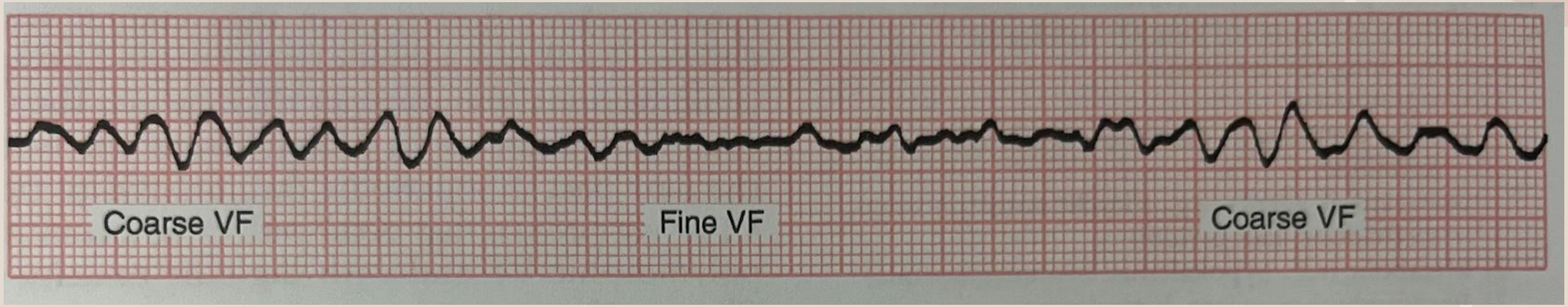
Ventricular Fibrillation

- Irregularly irregular
- Ventricular rhythm
- No P waves, QRS, or T waves
- Waves can be coarse or fine
- TX: immediately cardiovert (unsynchronized)
  - May need amiodarone and epi



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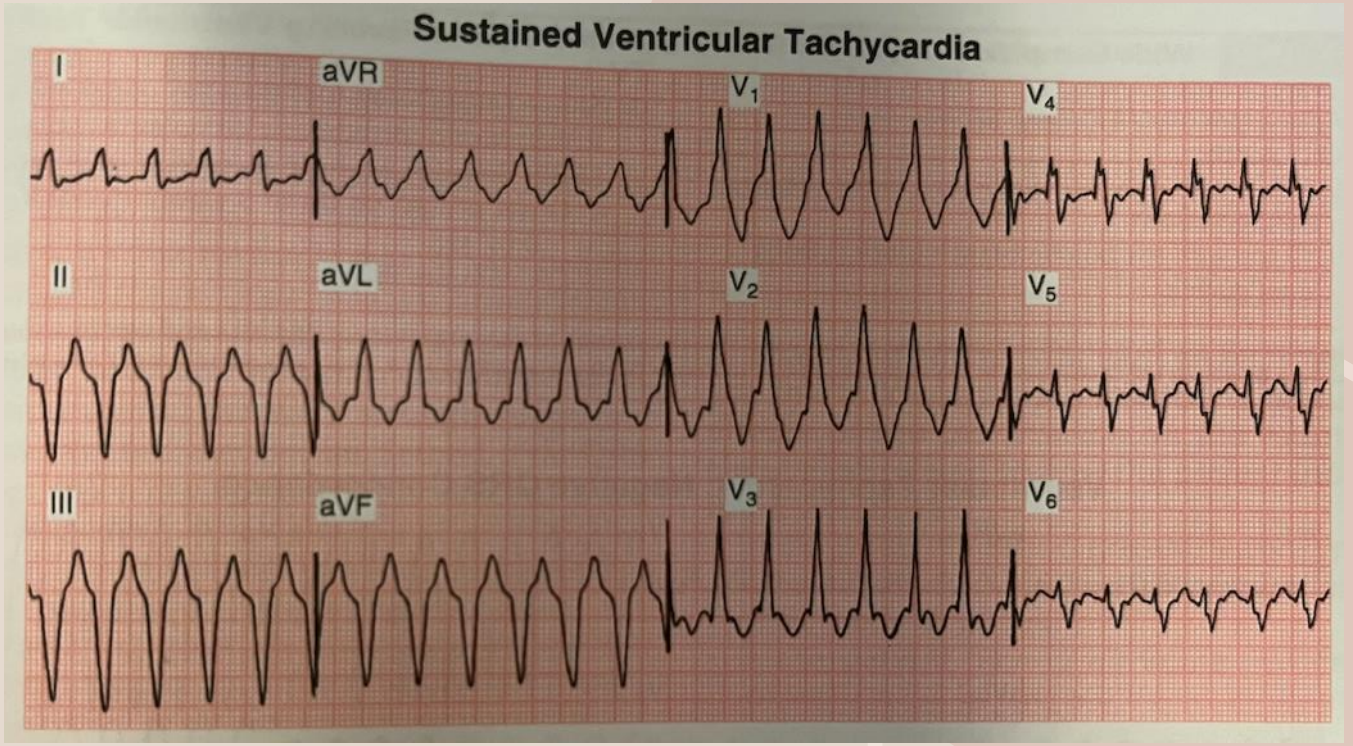
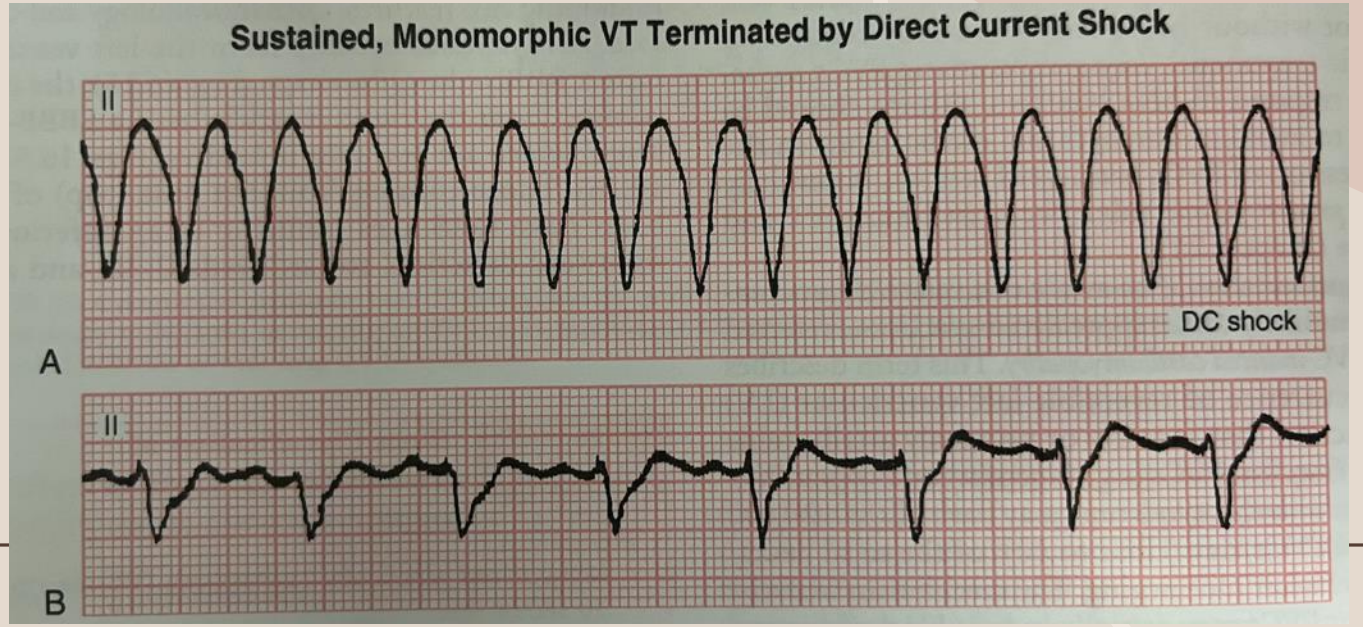
Ventricular Tachycardia

- Wide complex tachycardia
- At least 3 (or >) premature ventricular beats in a row
- Treatment
  - Stable- amiodarone, lidocaine
  - Unstable- CPR, defibrillation





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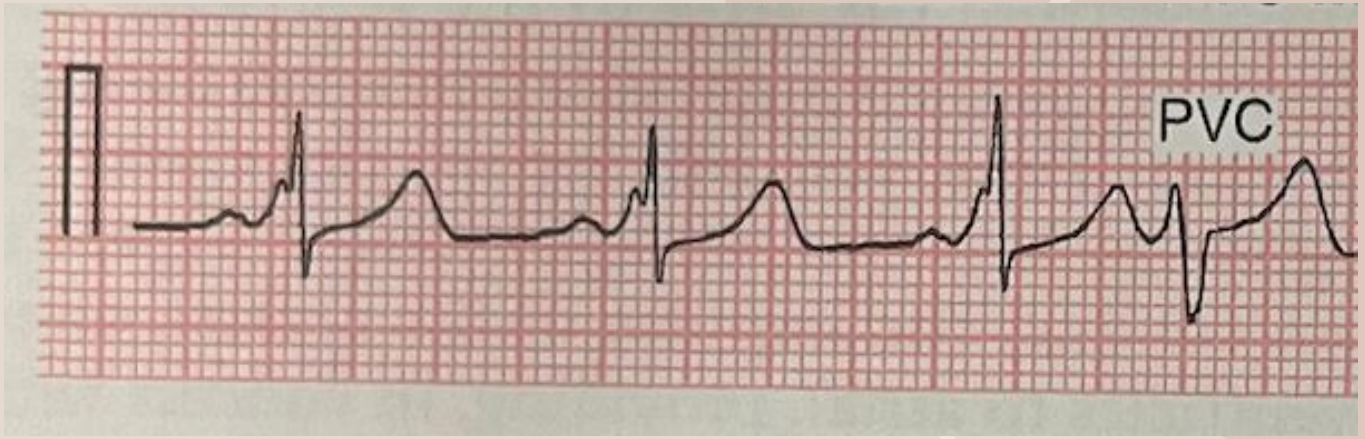
Wolff-Parkinson-White (WPW)

- Electrical signal between atria and ventricles goes through the “bundle of Kent’ (an abnormal pathway)
- Impulse is NOT delayed by AV node
- Causes ventricles to contract prematurely
- Key feature: **Delta wave**



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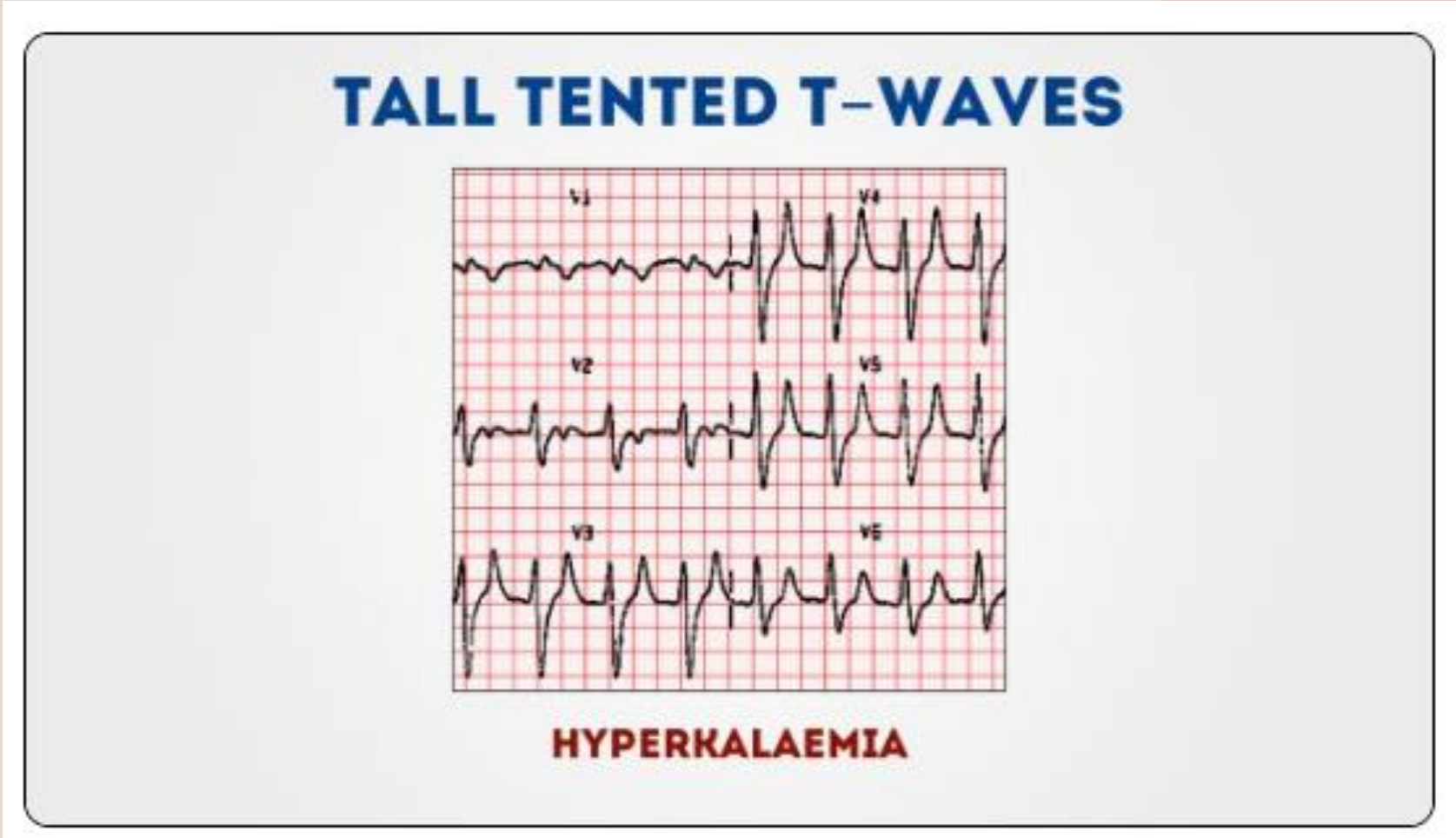
Hyperkalemia



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What about pacemaker spikes??

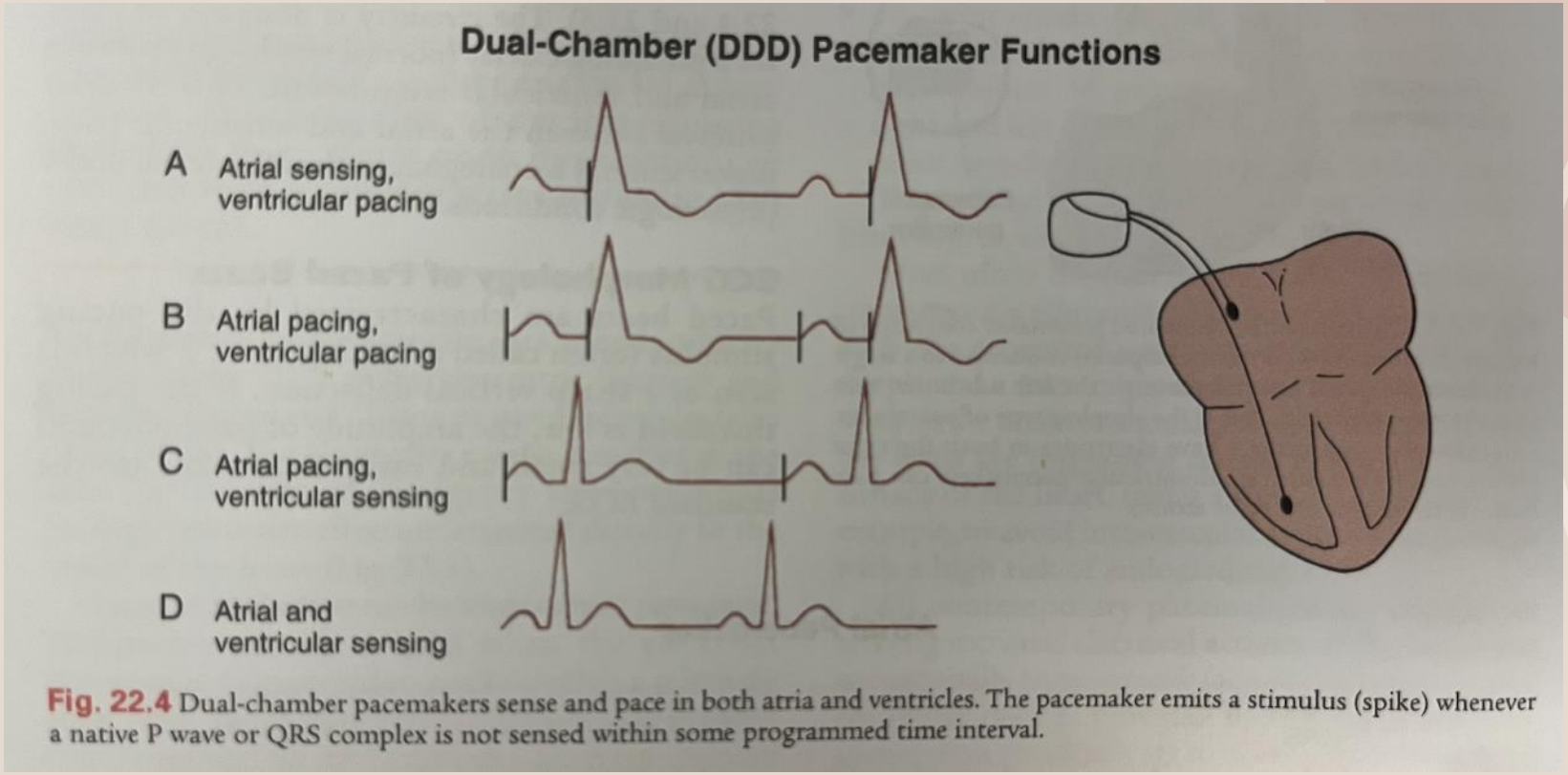

Fig. 22.4 Dual-chamber pacemakers sense and pace in both atria and ventricles. The pacemaker emits a stimulus (spike) whenever a native P wave or QRS complex is not sensed within some programmed time interval.

Goldberger, A. L., Goldberger, Z. D., & Shvilkin, A. (2023). *Goldberger's clinical electrocardiography: A simplified approach* (10th ed.). Elsevier - Health Sciences Division.

thank you

Sarah Schettle, PA-C, MS, MBA

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Extra slides

Left Bundle Branch Block (LBBB)

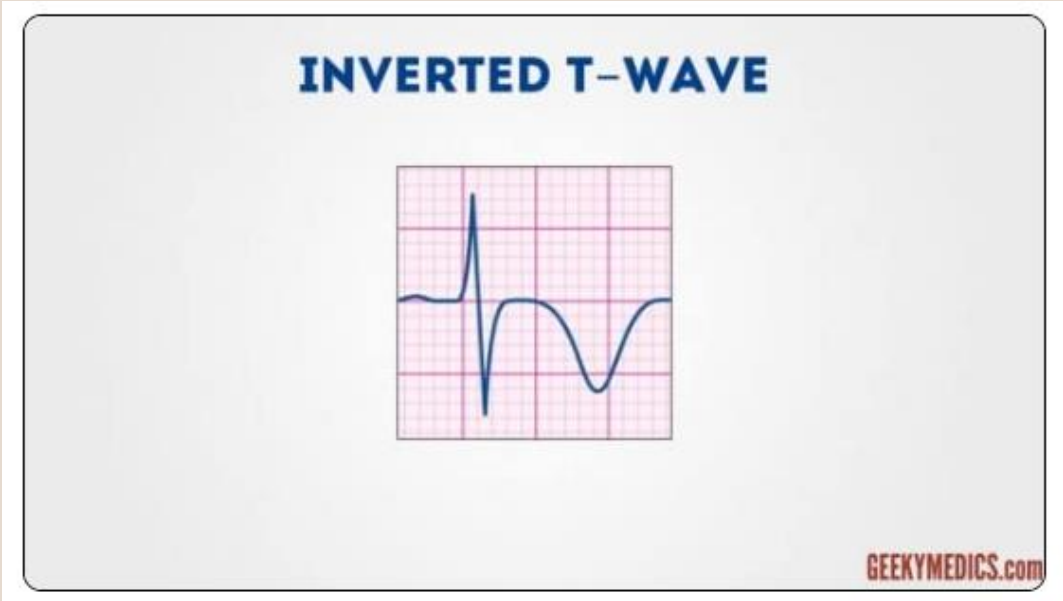
- Left: R and R’ (upward bunny ears) in **V4-V6**

Right Bundle Branch Block (RBBB)

- Right: R and R’ (upward bunny ears) in **V1-V3**

Bundle branch blocks

- T waves are normally inverted in V1 and inversion in lead III is a normal variant.
- Inverted T waves in other leads are a nonspecific sign of a wide variety of conditions:
  - (V4-6 in LBBB and V1-V3 in RBBB)



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Sick Sinus Syndrome

- Brady-tachy:
  - **bradycardia** alternates with **tachycardia**
- Sinus arrest:
  - prolonged absence of sinus node activity
  - **(absent P waves) > 3 seconds**