Interpretation of the Electrocardiogram

VANDERBILT HEART

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Disclosures:

Research funding Medtronic

Learning Objectives:

1. Learners will comprehend how normal cardiac depolarization generates the 12 lead ECG.

2. Learners will be able to describe how alterations in ventricular activation change the 12 lead ECG, such as in BBB or VT.

3. Learners will be able to identify ECG changes indicative of acute myocardial infarction

4. Learners will be able to differentiate sinus rhythm, atrial fibrillation, SVT, and VT.

5. Learners will be able to identify normal cardiac electronic device behavior on ECG.

Interpreting an ECG
Do you Have a template?

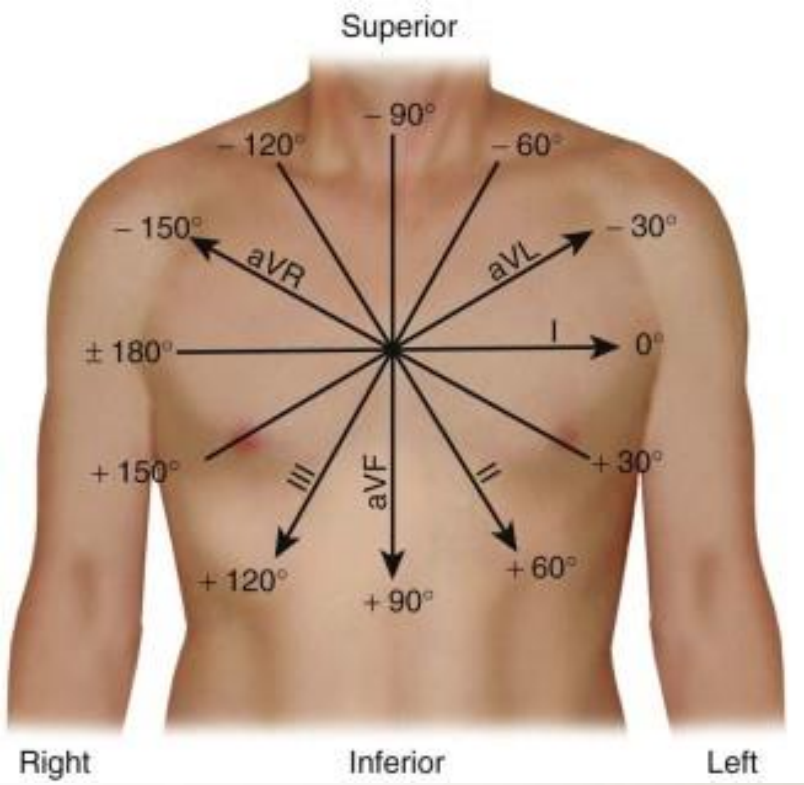
- Rate
- Rhythm
- Intervals
- Axis
- Hypertrophy
- Infarct

Generation of the Electrocardiogram

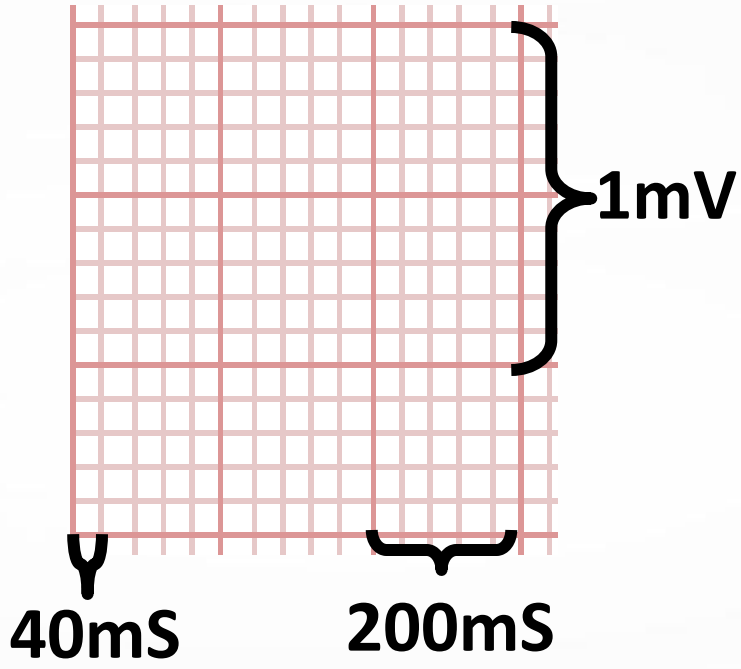
The ECG records voltage changes reflected on the body surface from depolarization and repolarization of myocardial cells.

9 electrodes are placed at predefined locations on the body to record these voltage changes.

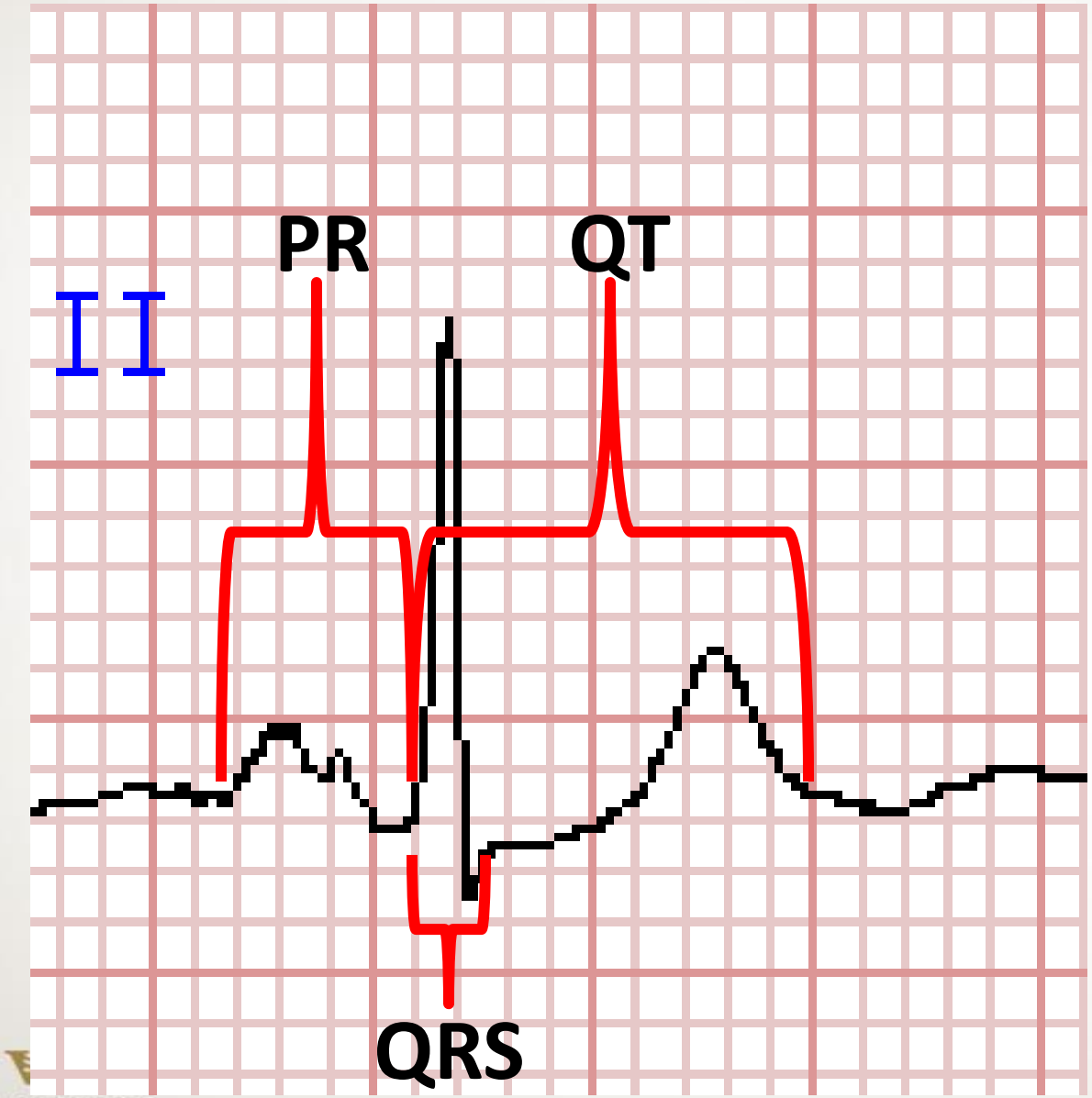
In general **depolarization** moving **toward** an electrode will create a **positive** voltage deflection.



Timing and Scale



Intervals

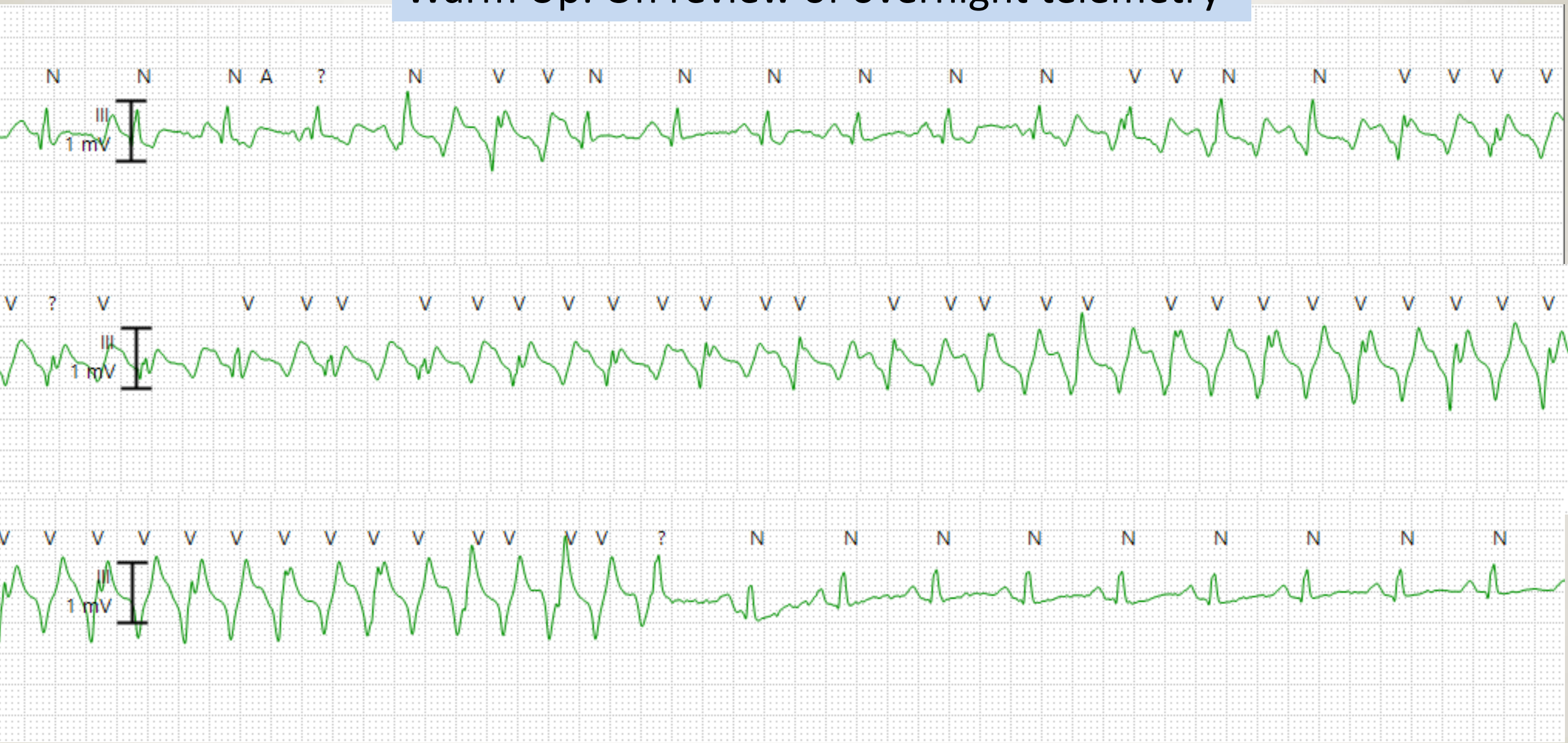


PR < 200ms

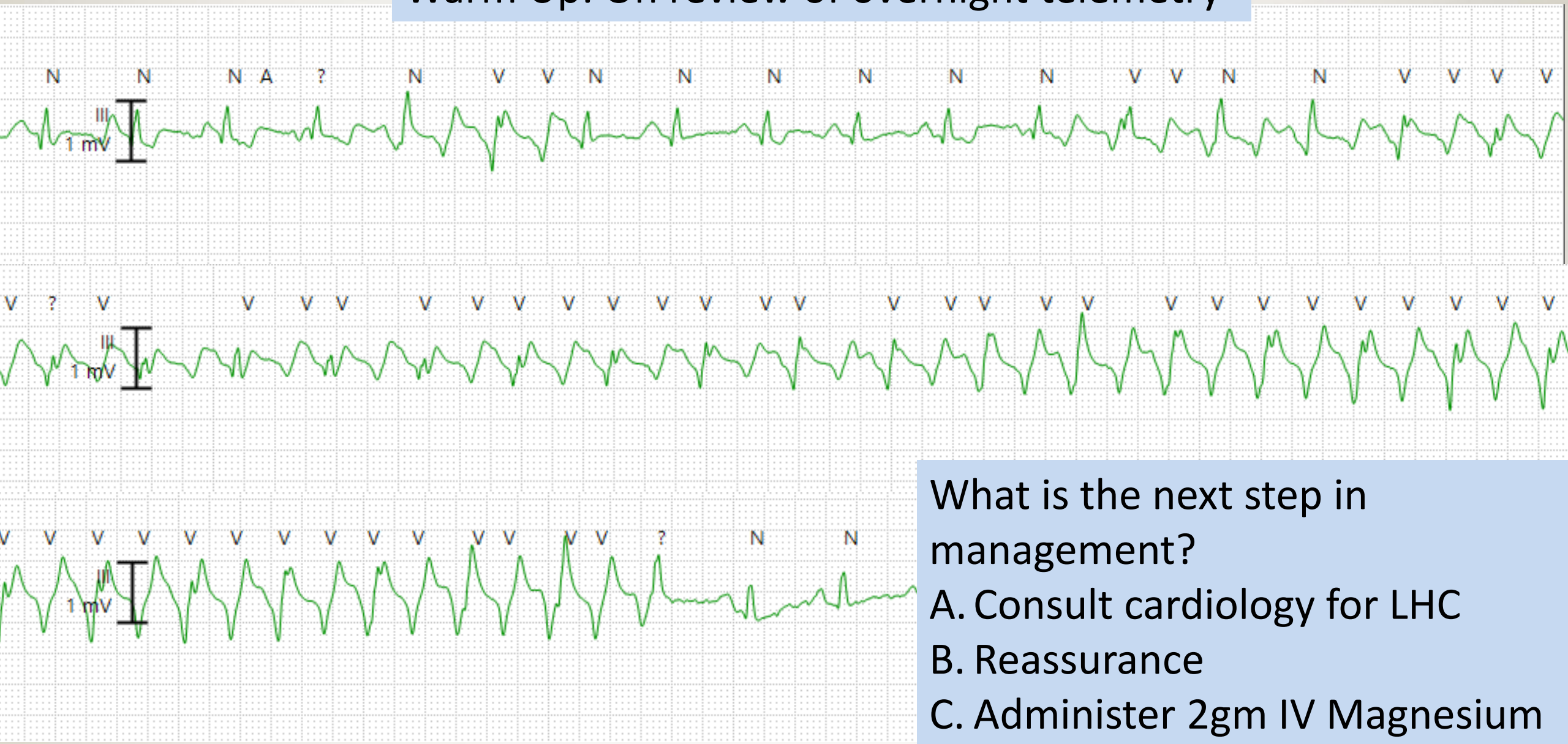
QRS < 120ms

QT < 450ms or half RR

Warm Up: On review of overnight telemetry



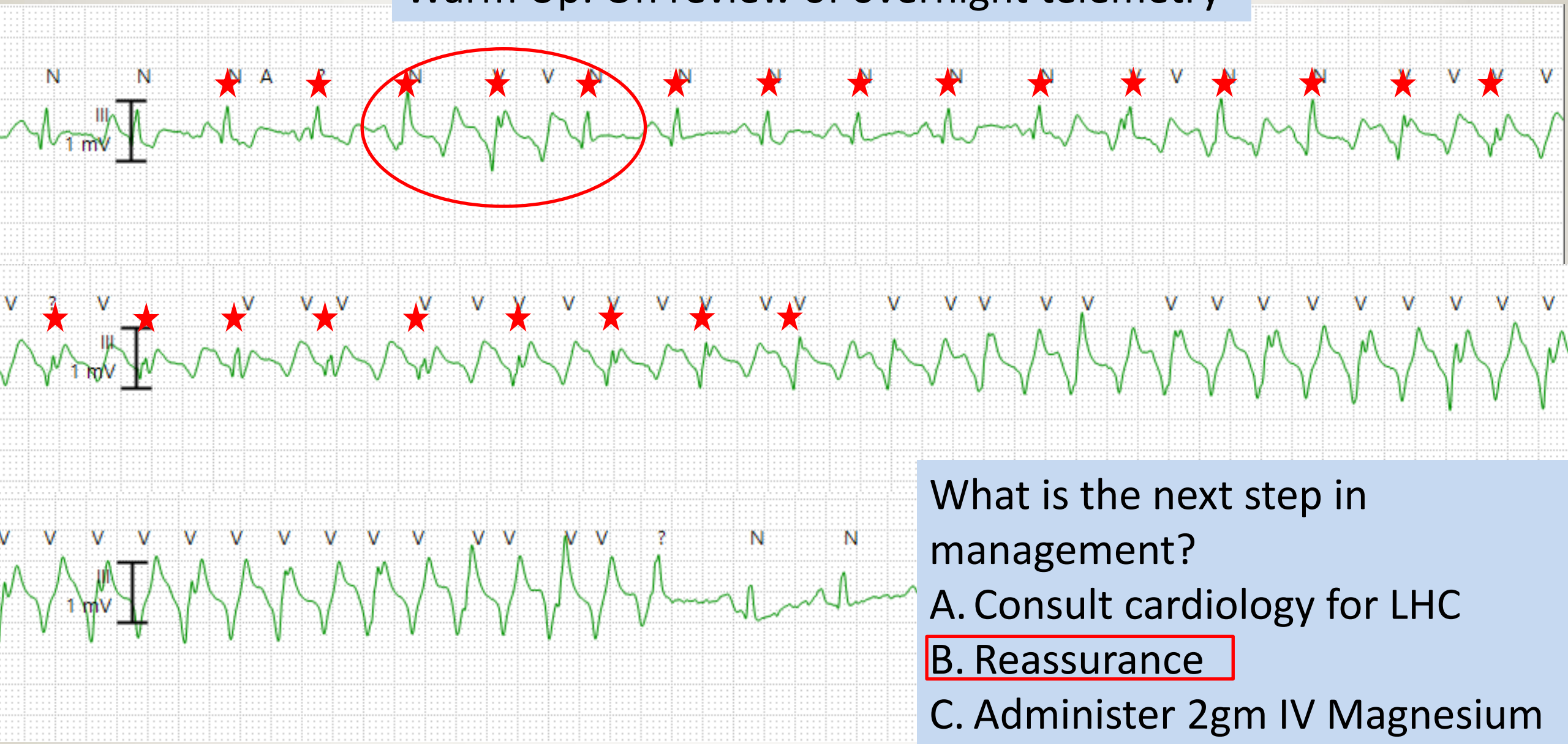
Warm Up: On review of overnight telemetry



What is the next step in management?

A. Consult cardiology for LHC
B. Reassurance
C. Administer 2gm IV Magnesium
D. Cardioversion

Warm Up: On review of overnight telemetry



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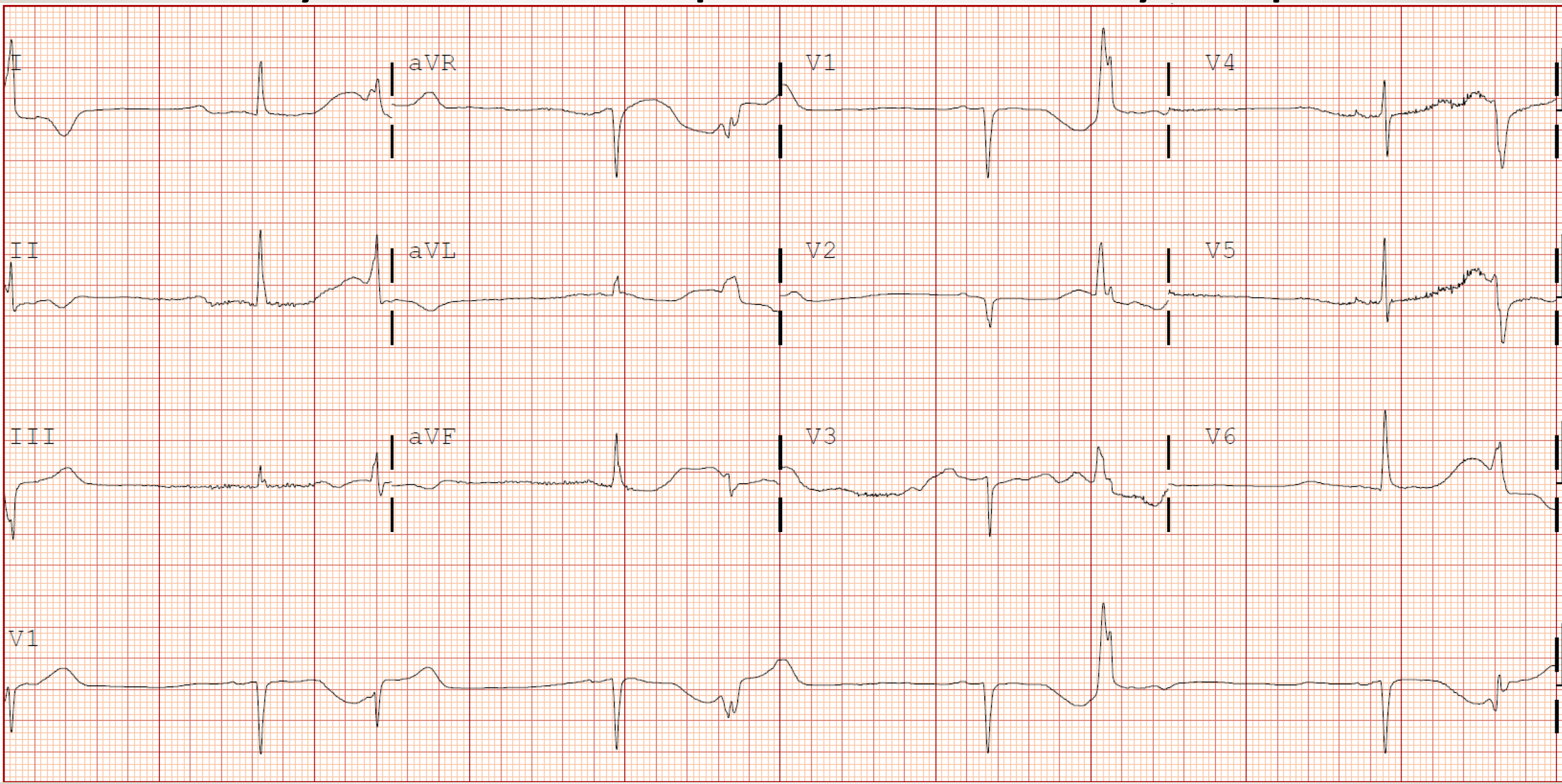
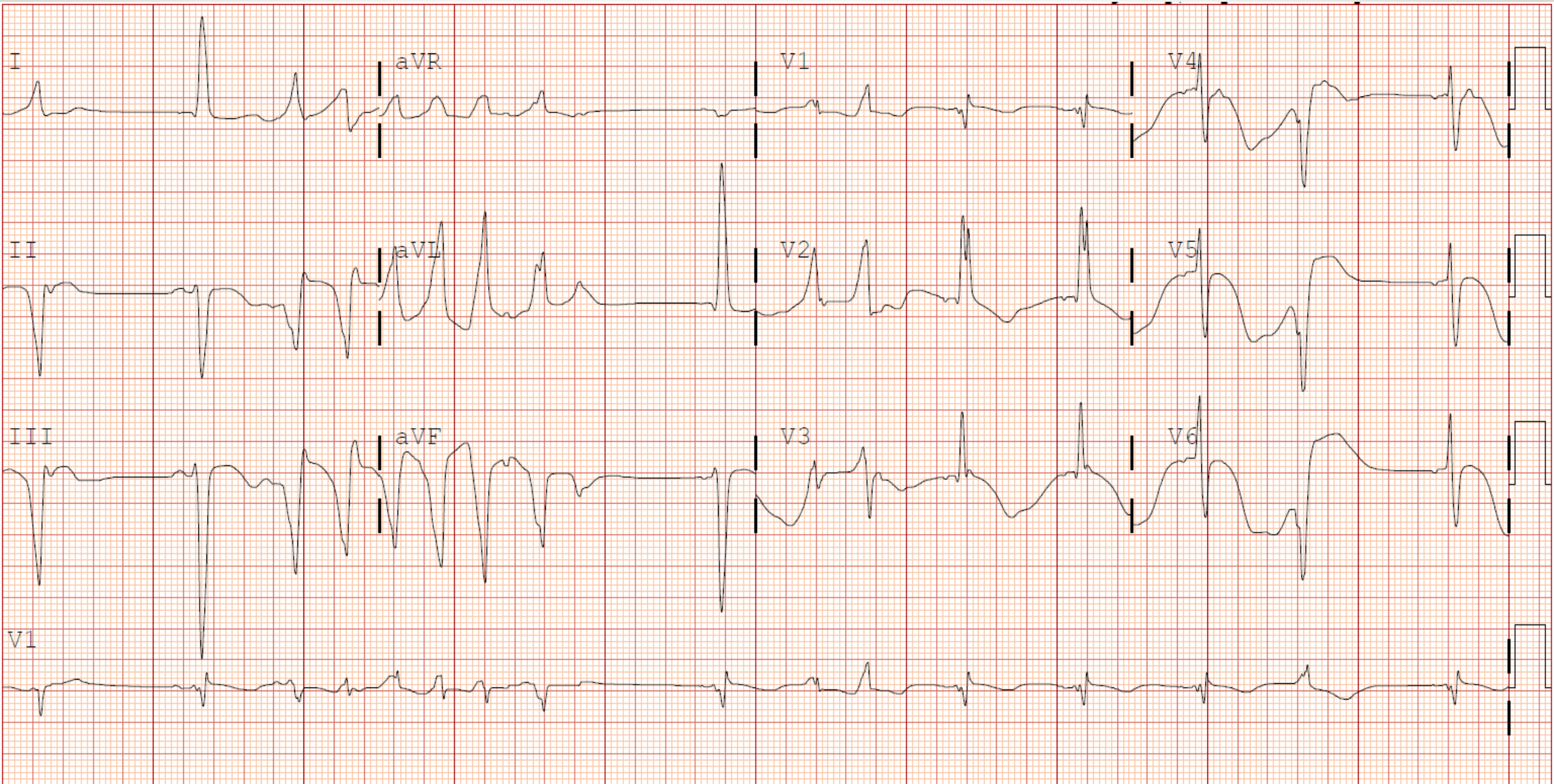
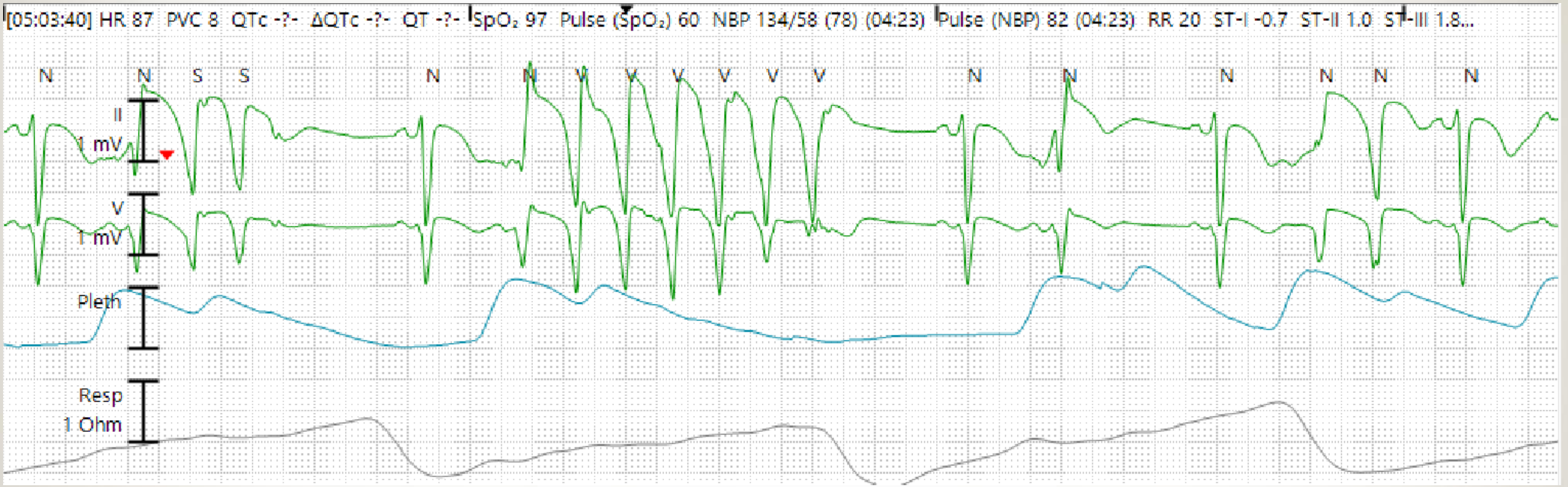
60yo M with AF presents with syncope



78F with malignancy, nausea receiving Ondansetron and Haloperidol





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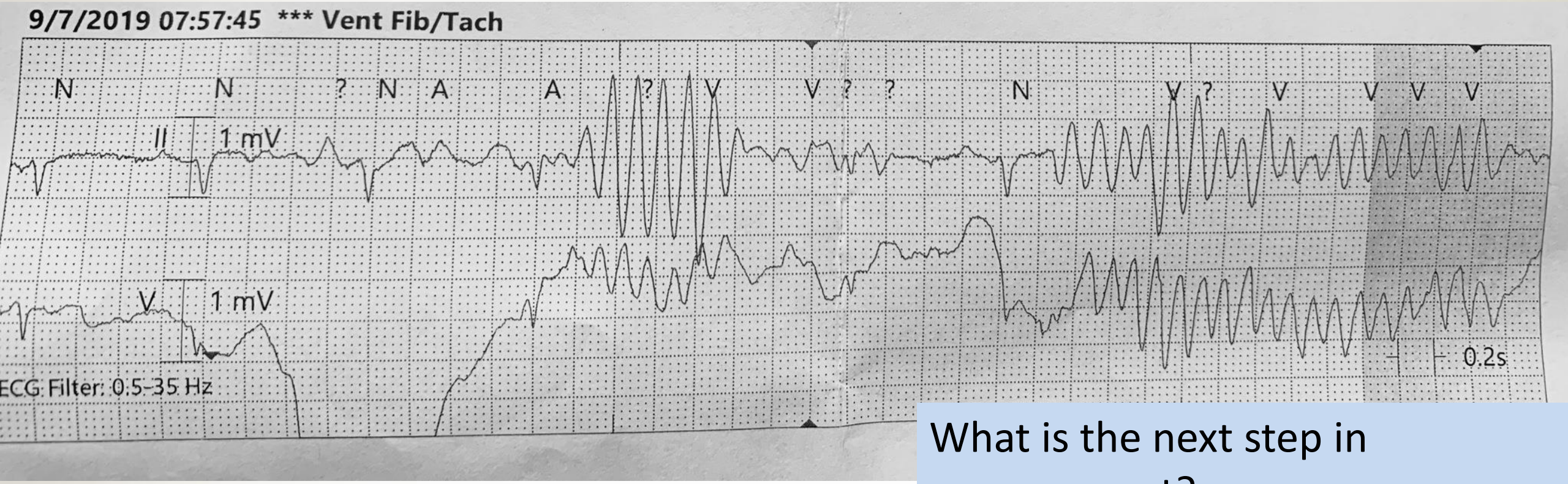
Paged by Tele Loading Dofetilide



What is the next step in management?

A. Stop Dofetilide

B. Check Mg/K

C. Go back to sleep

D. Notify EP for pacing

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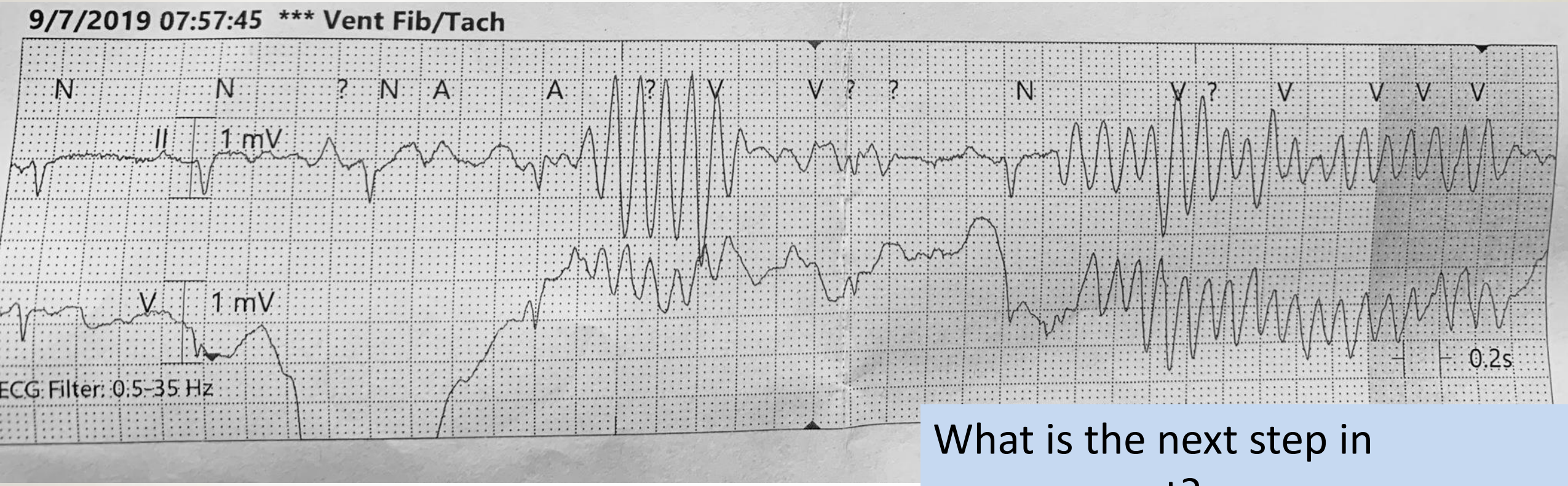
Paged by Tele Loading Dofetilide



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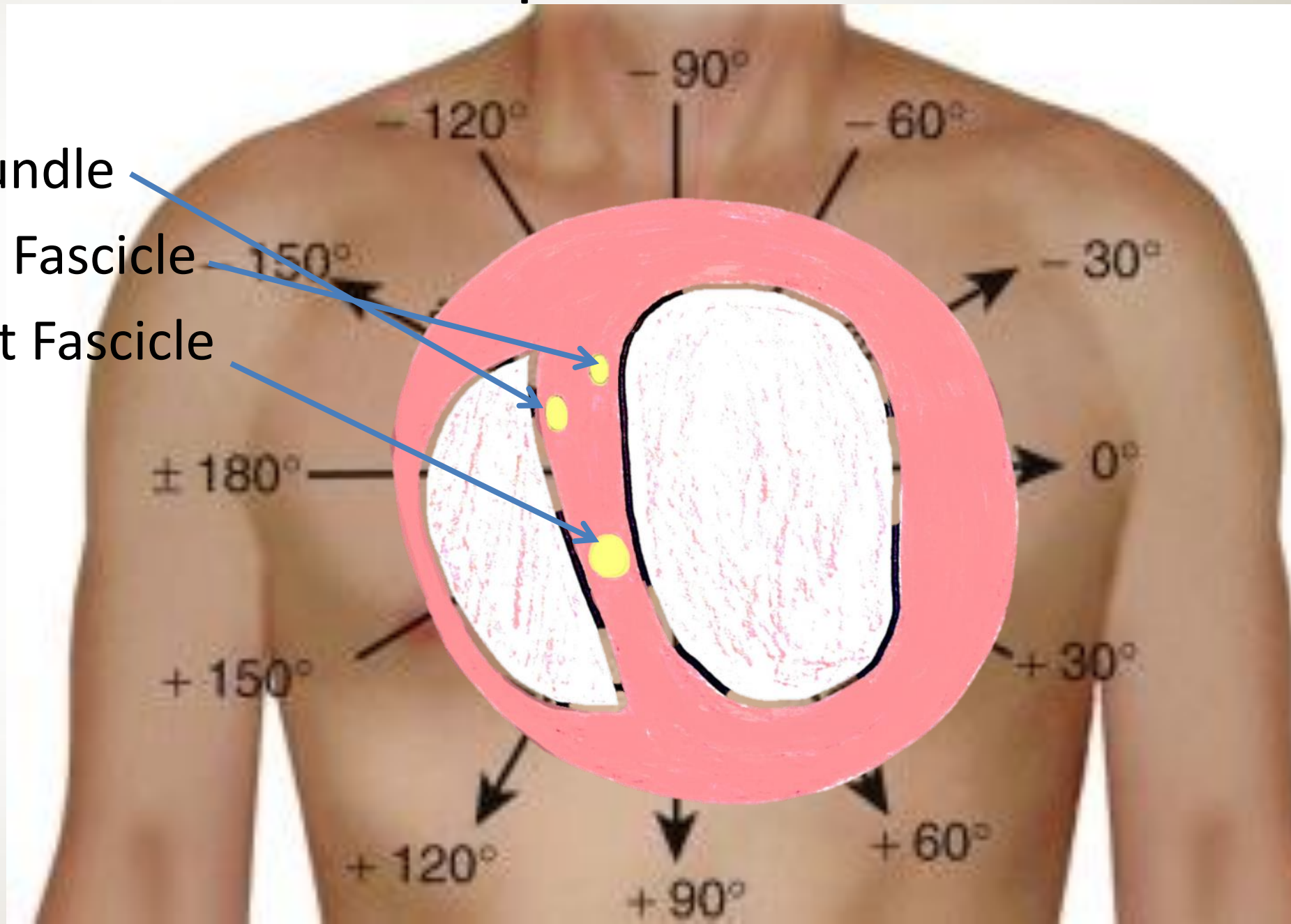
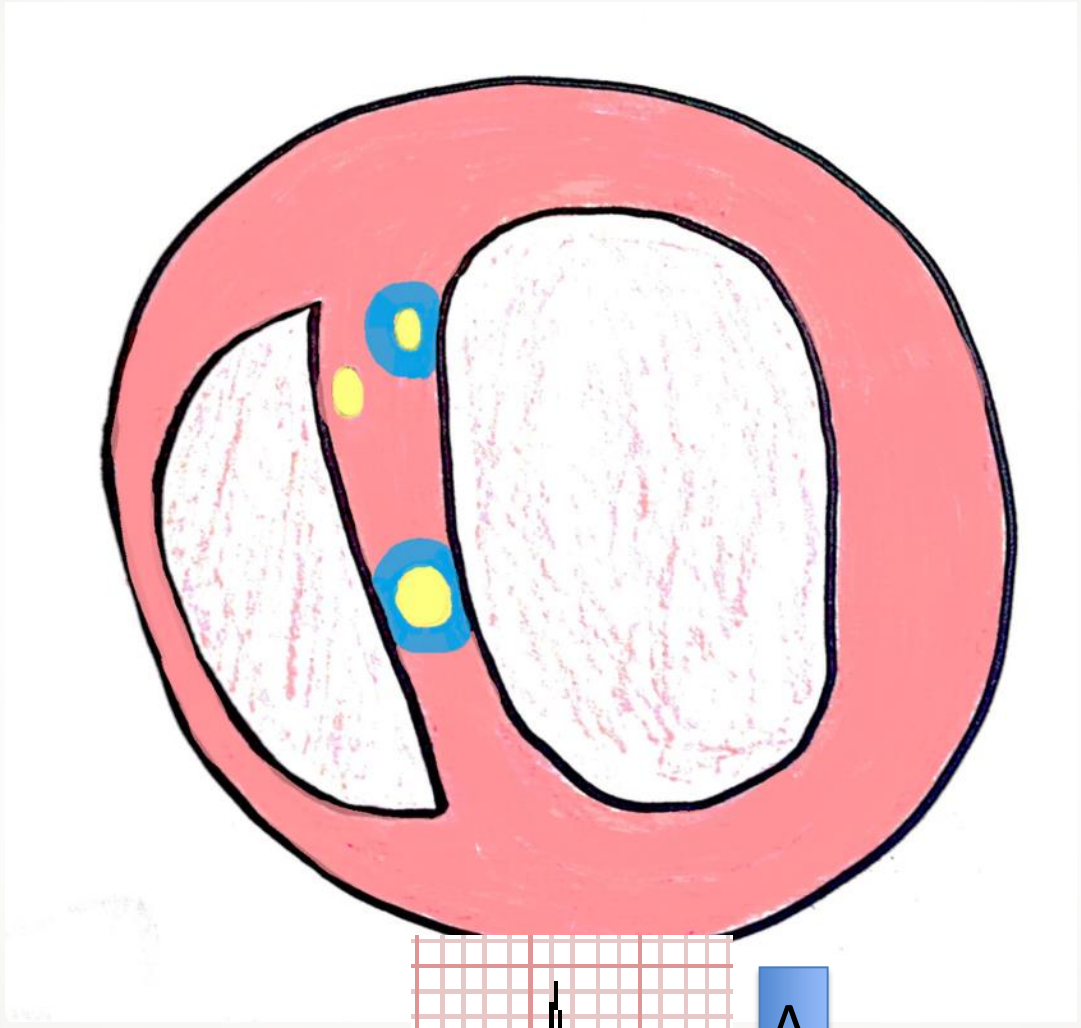
Now let's examine frontal plane activation

- Right Bundle
- Left Ant Fascicle
- Left Post Fascicle

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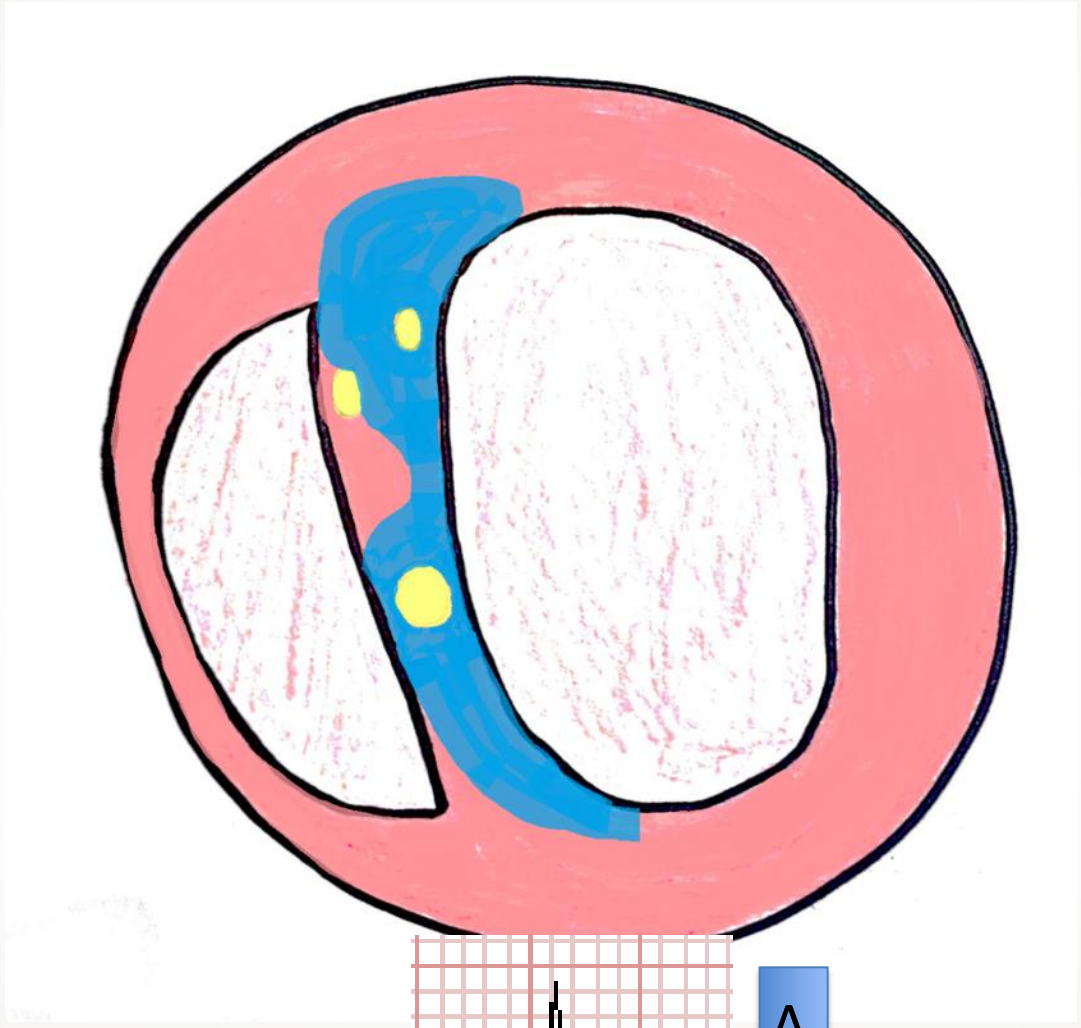
AVF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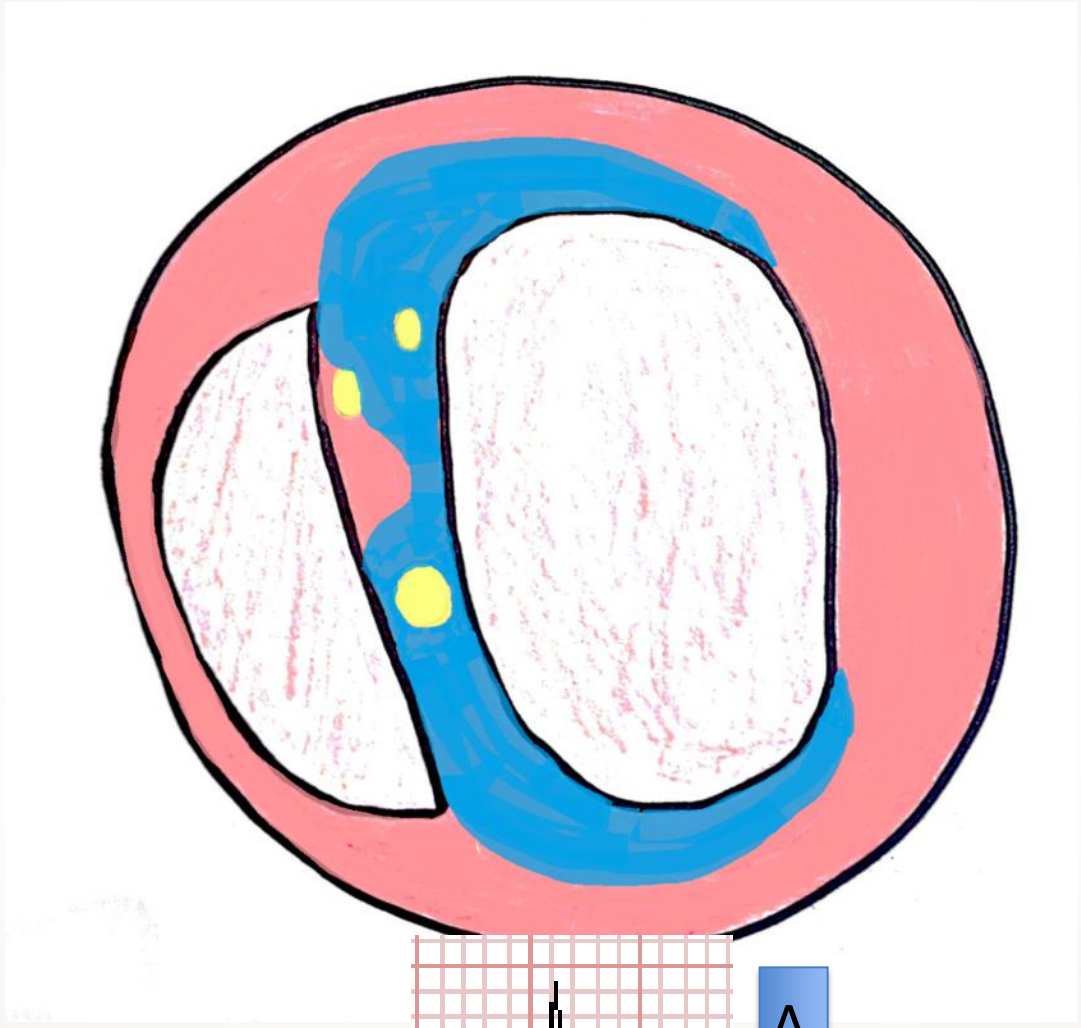
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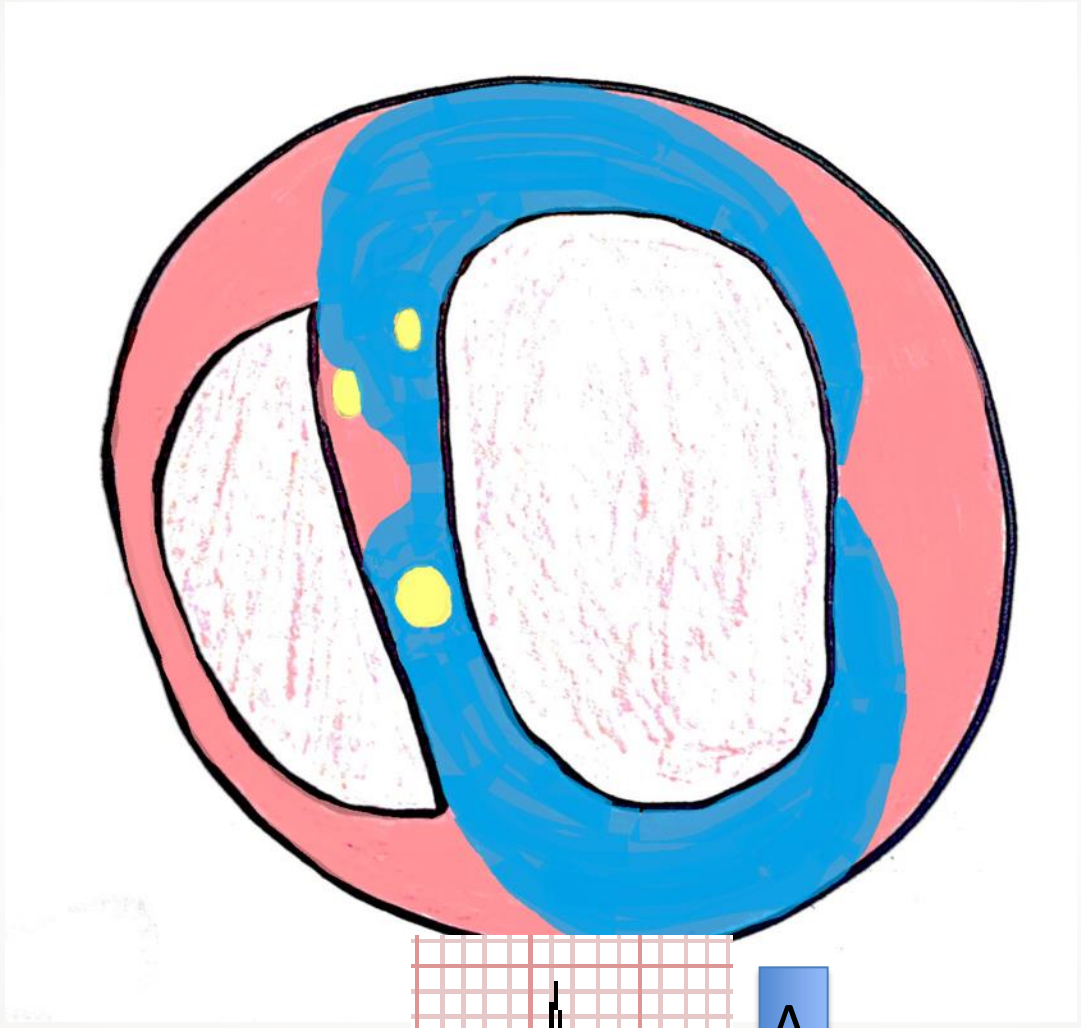
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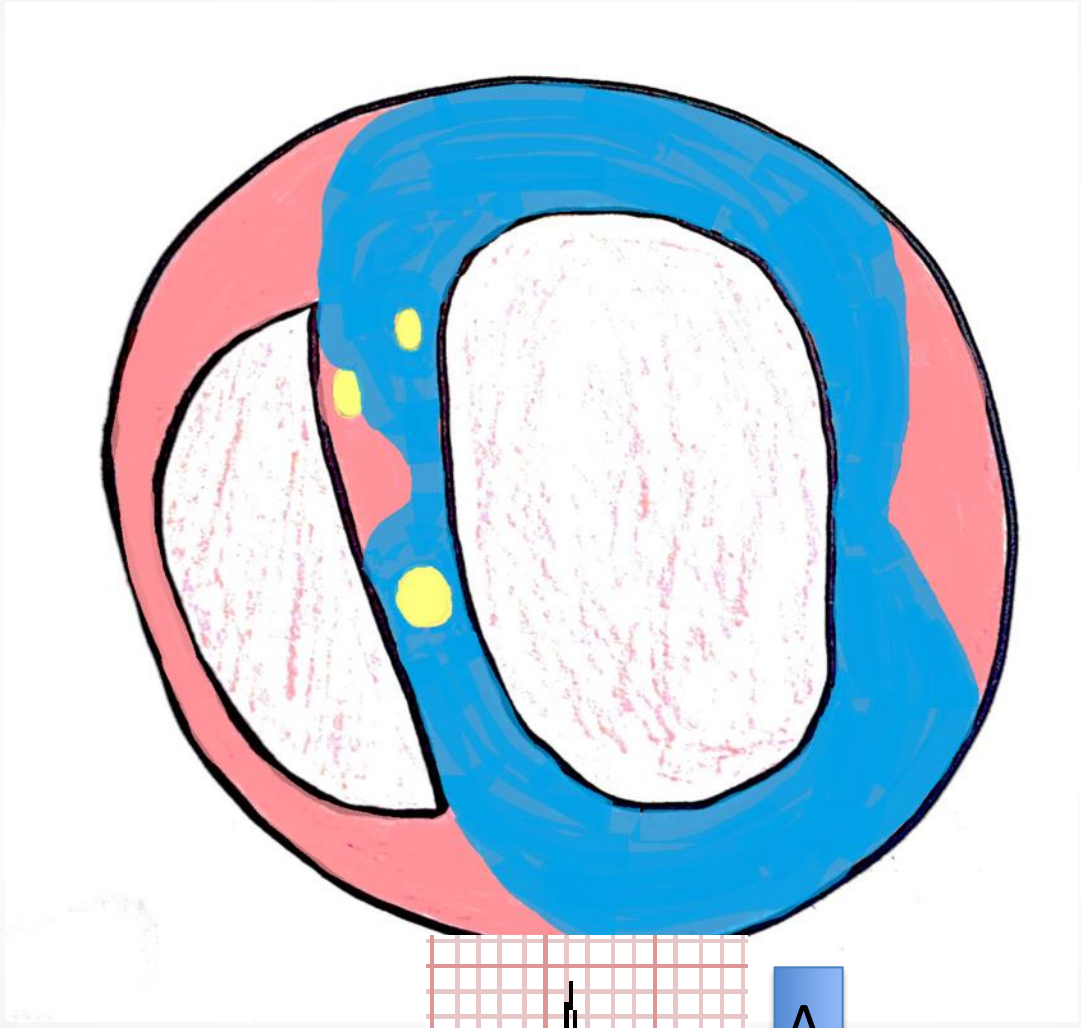
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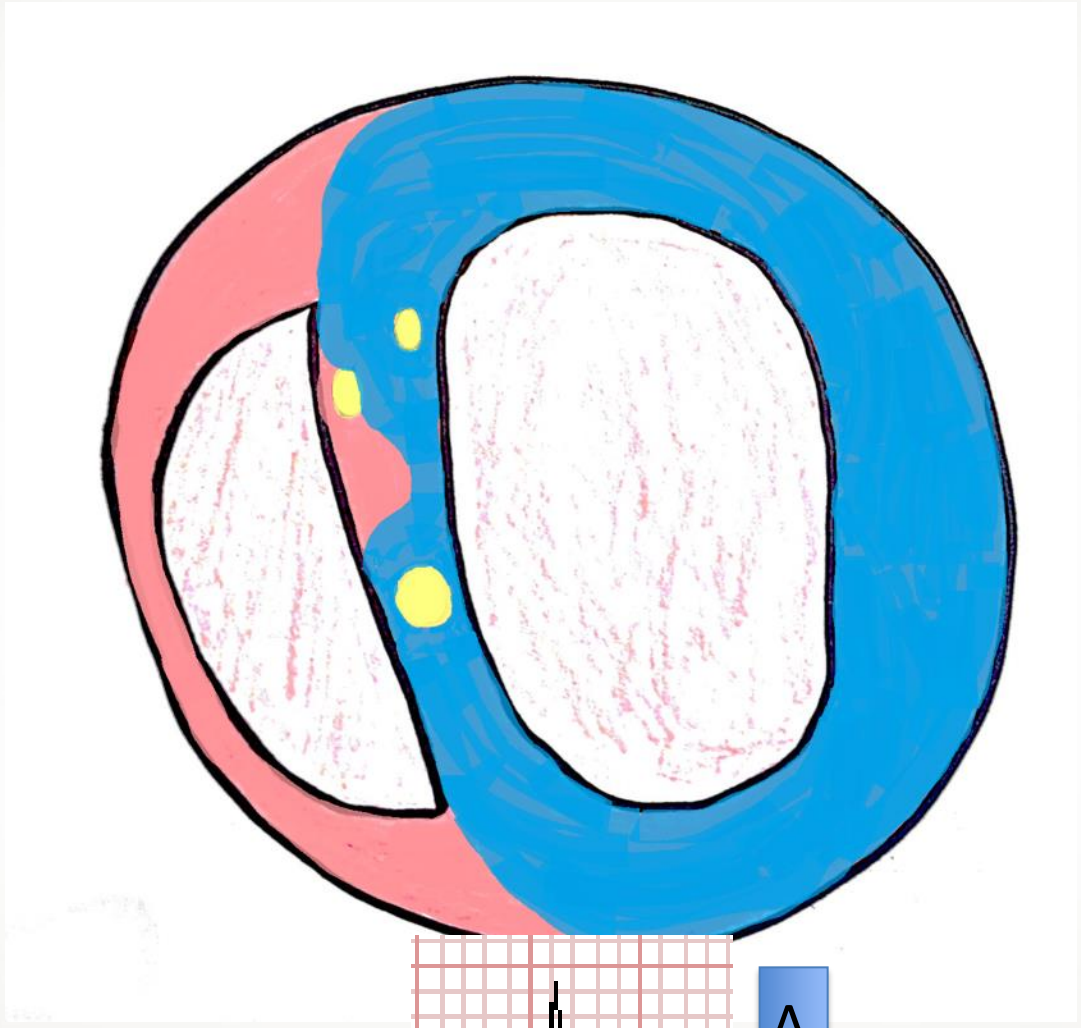
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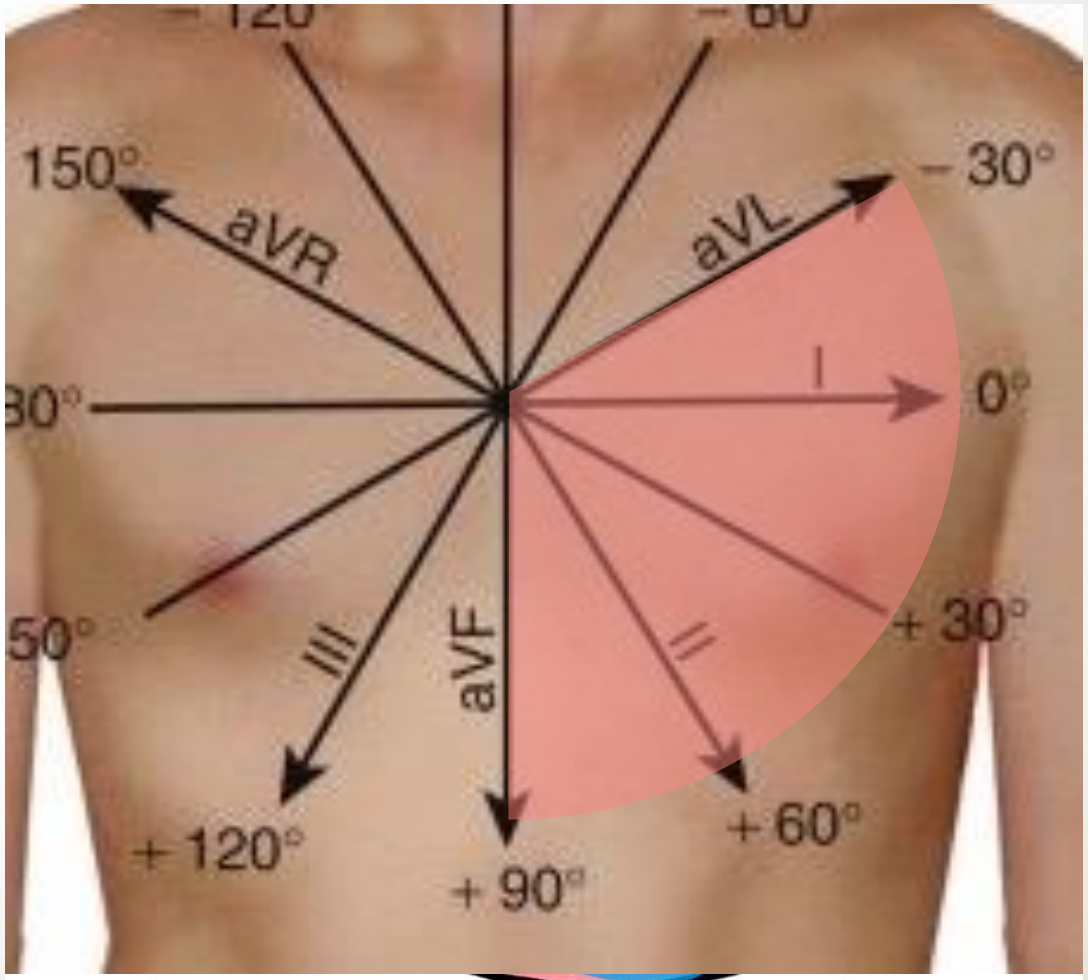
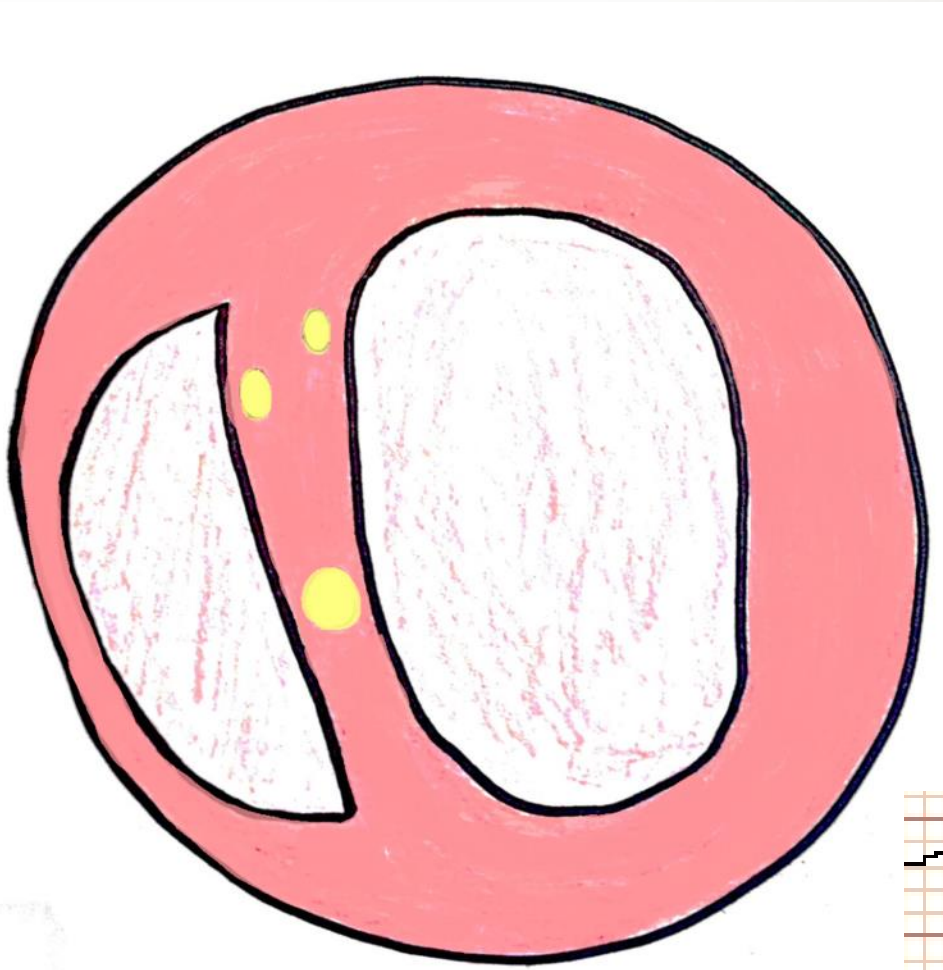
Frontal Axis

- Now you can imagine how this generates the frontal axis.
- Normal frontal axis is from -30 to +90



Left Anterior Fascicular Block

- How this would be different if the anterior fascicle were blocked?



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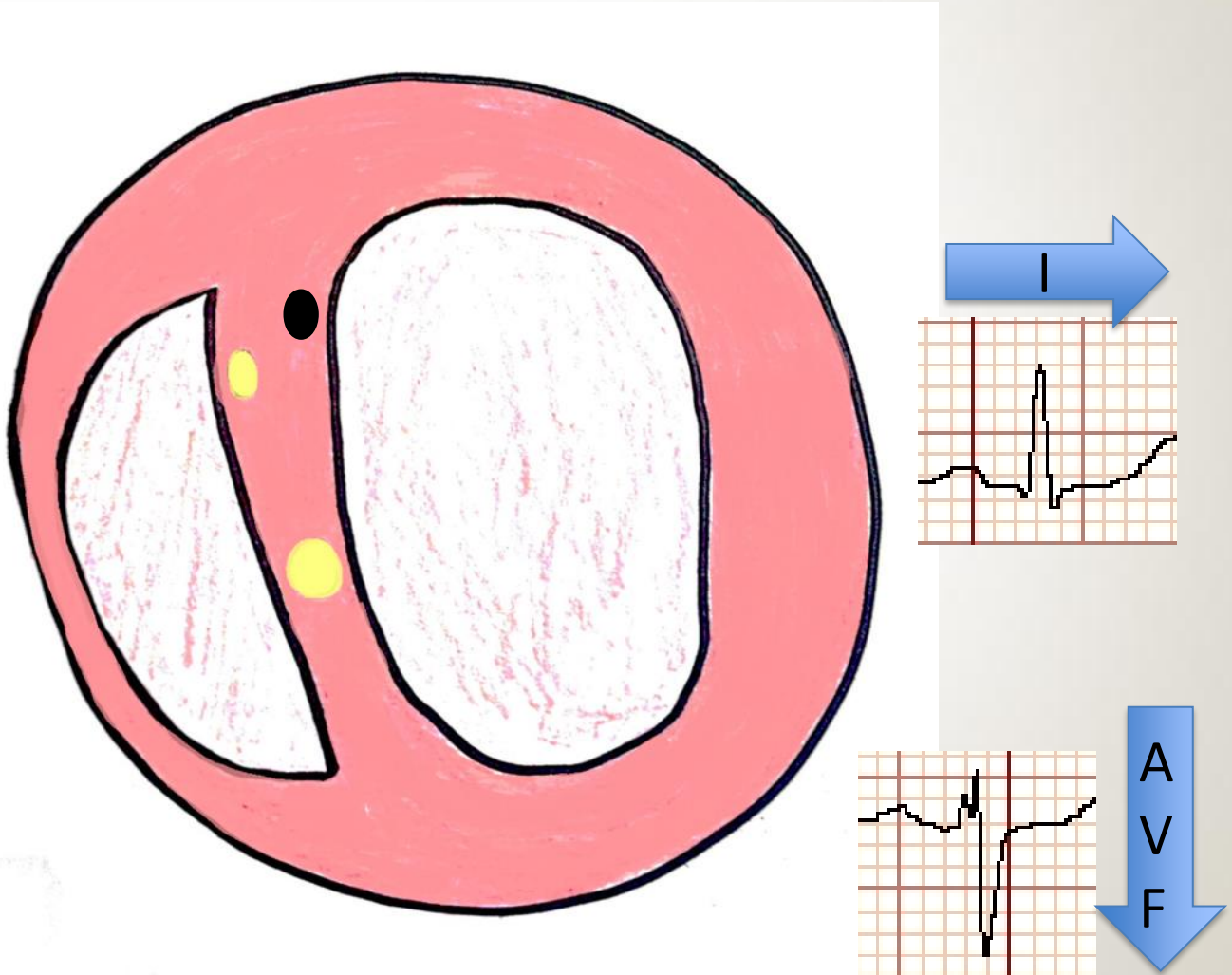

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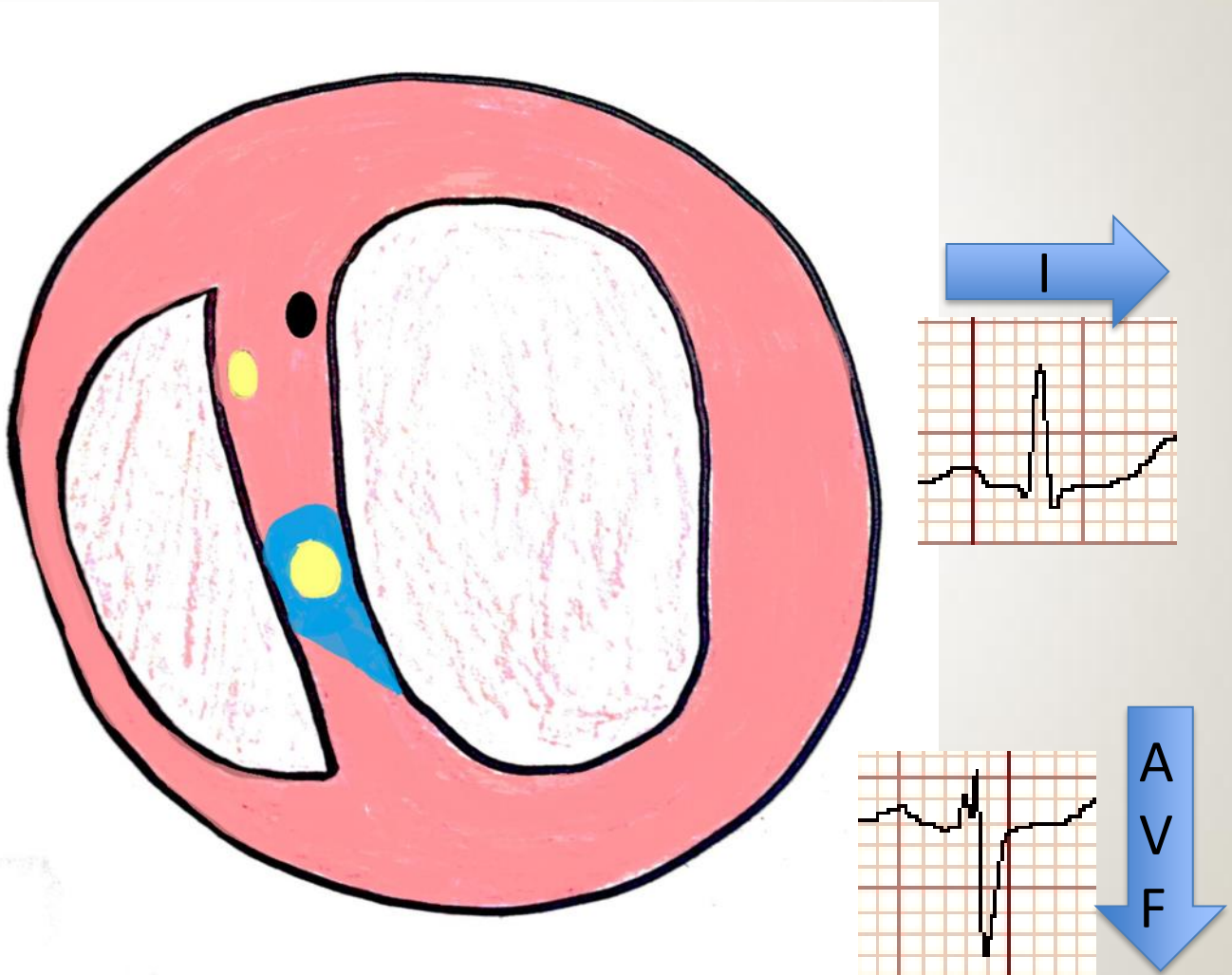

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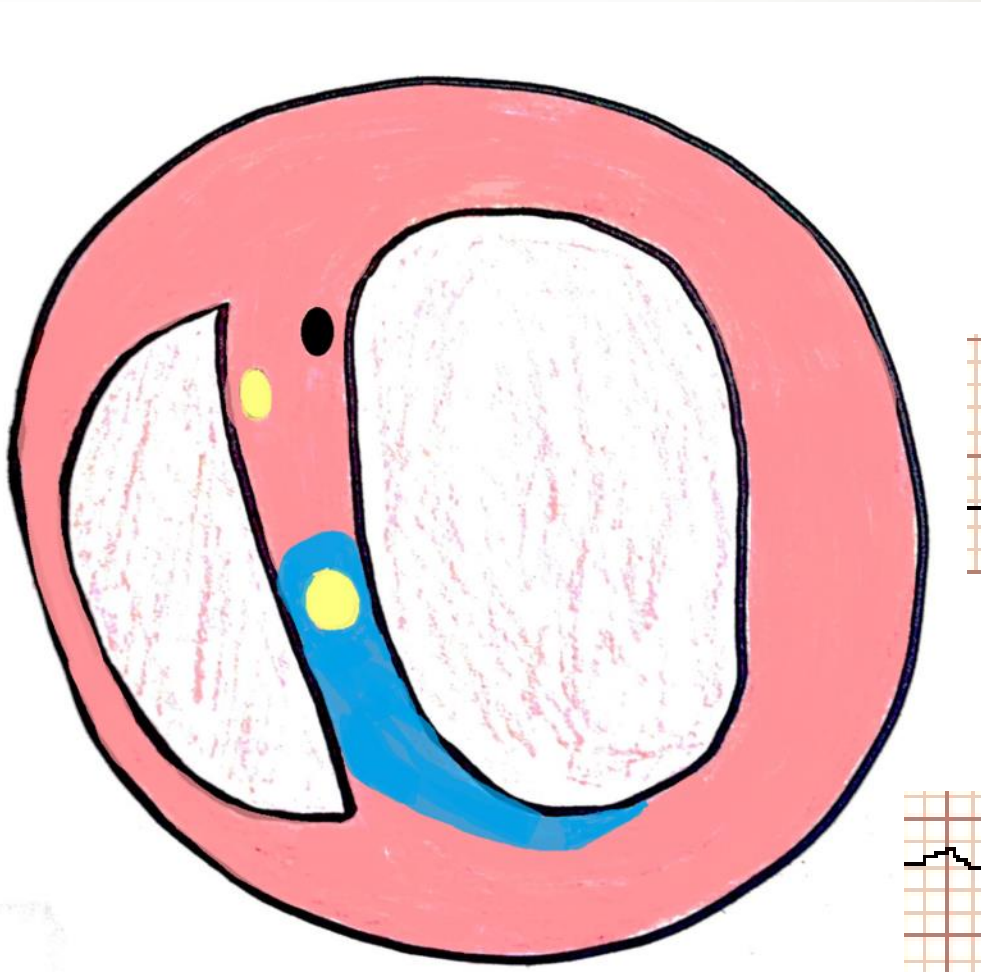

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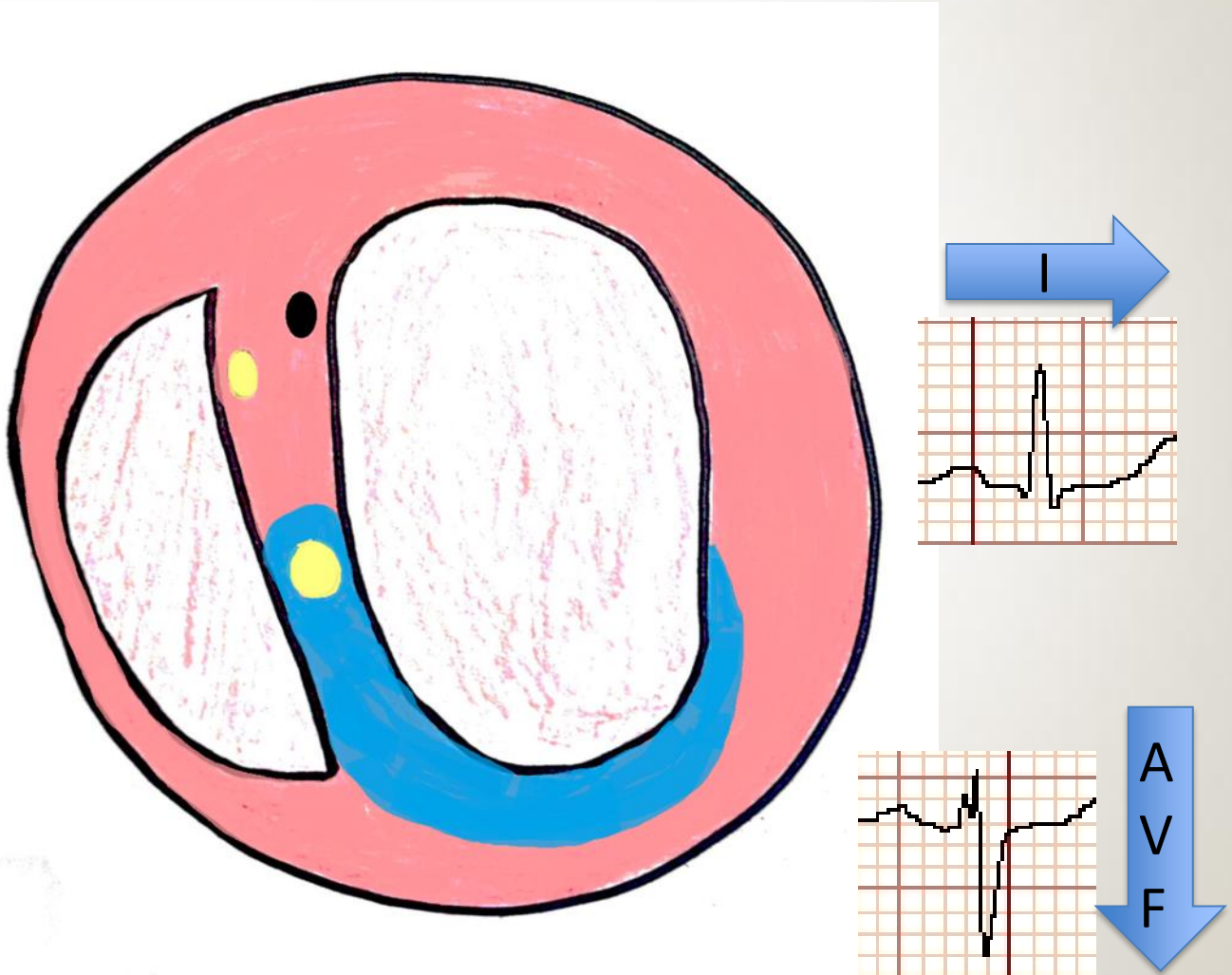

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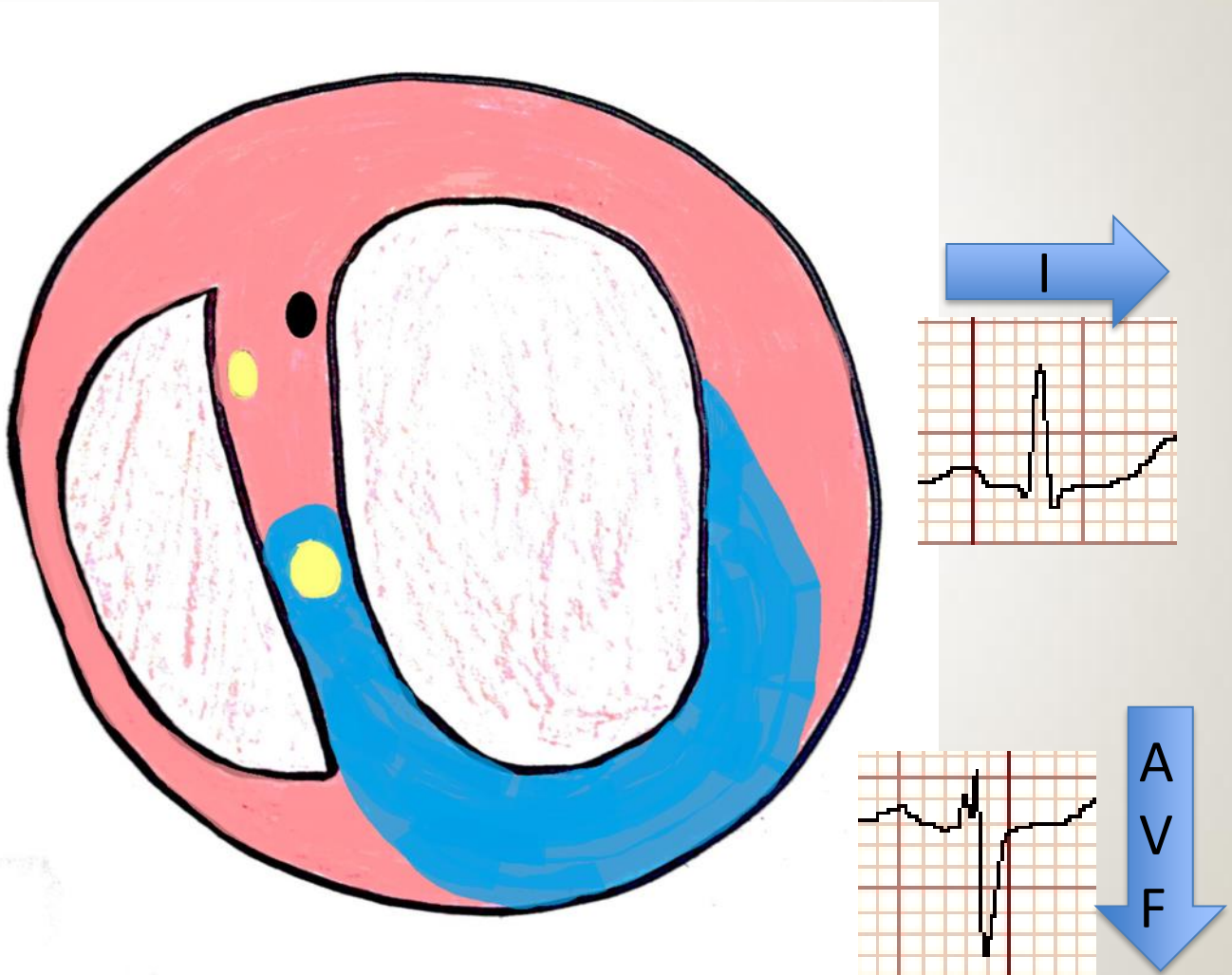

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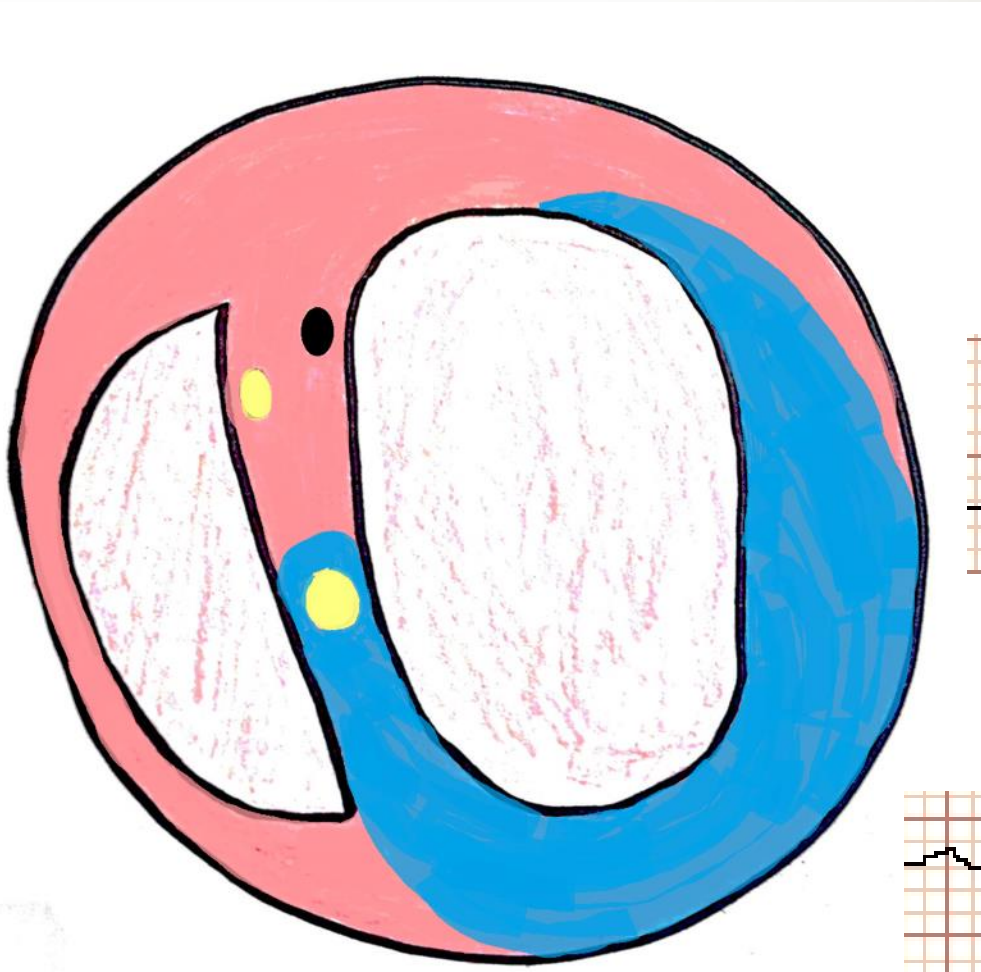

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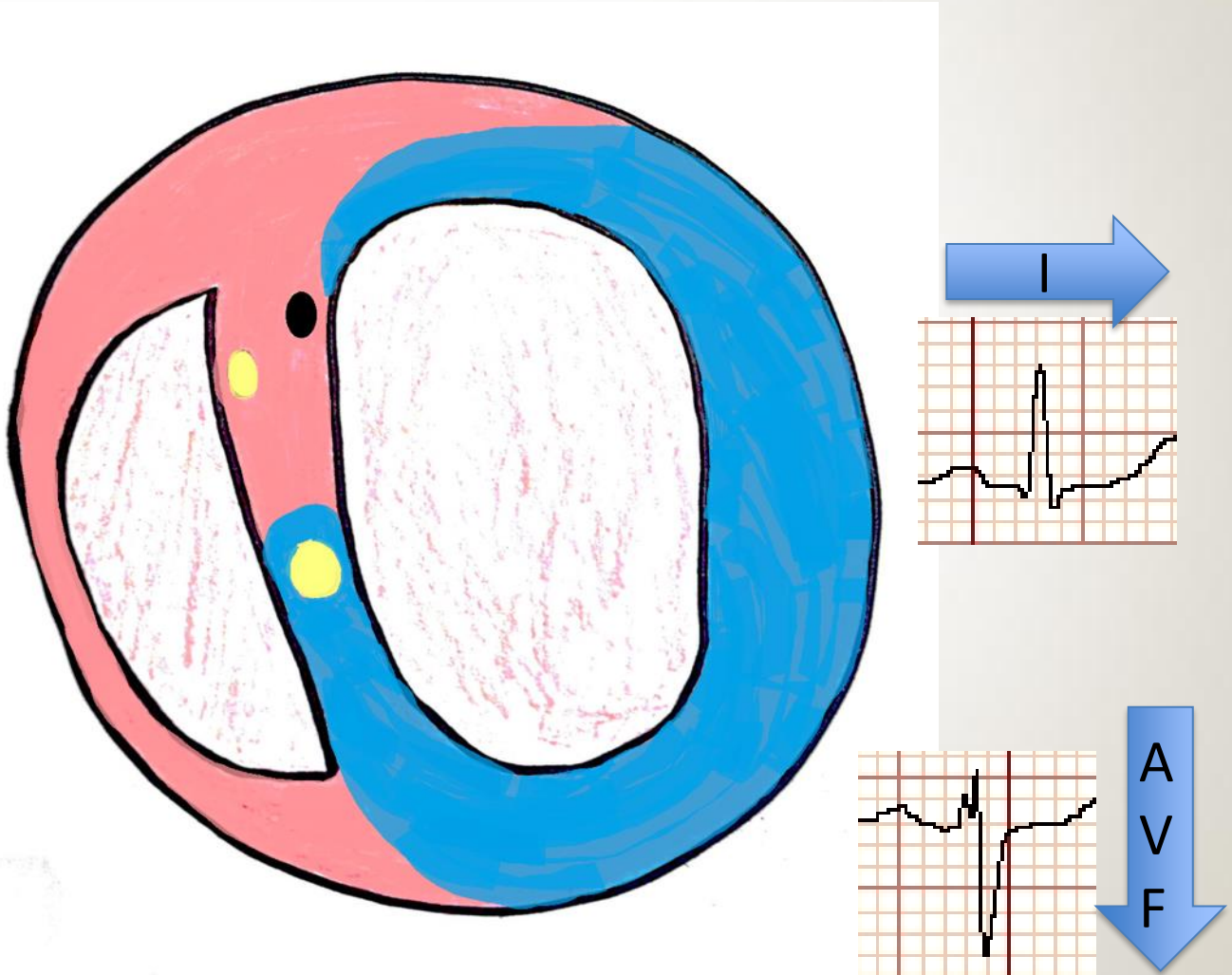

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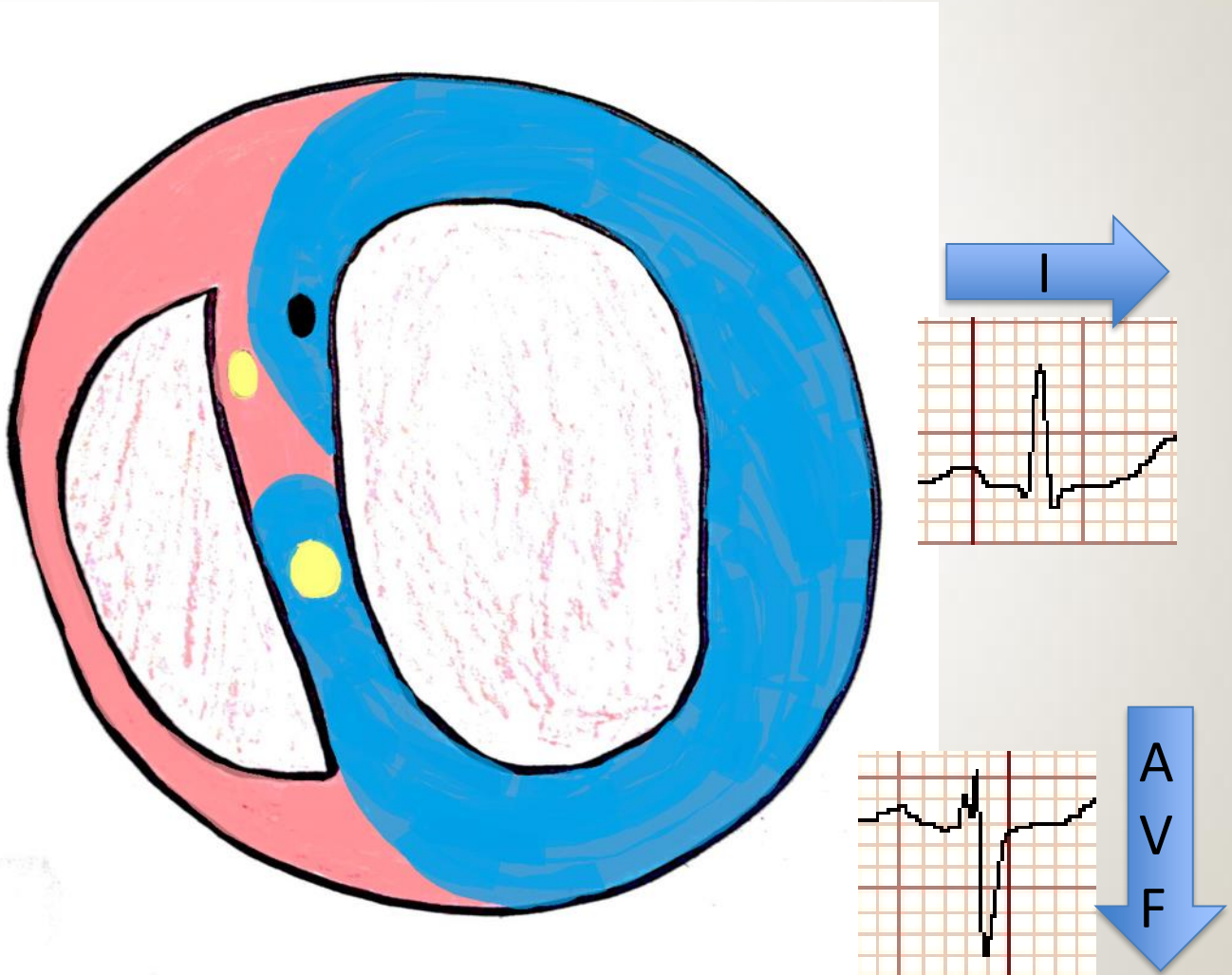

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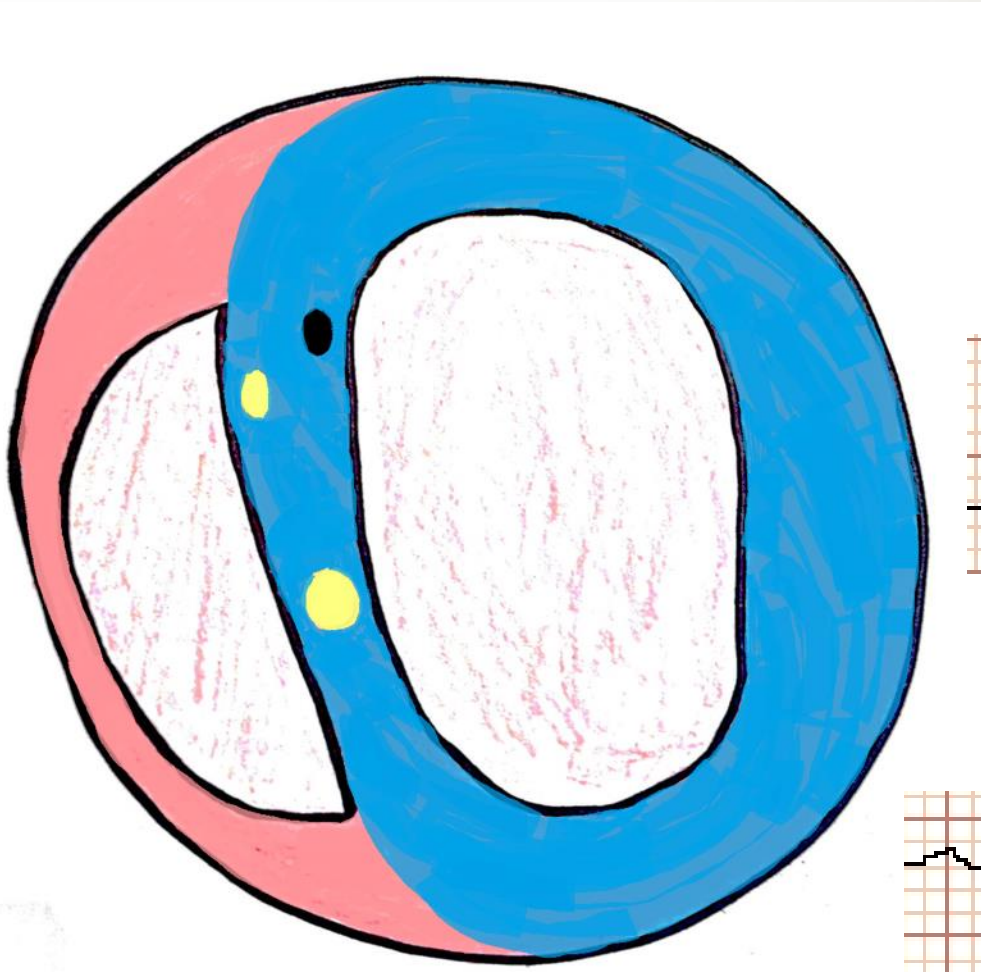
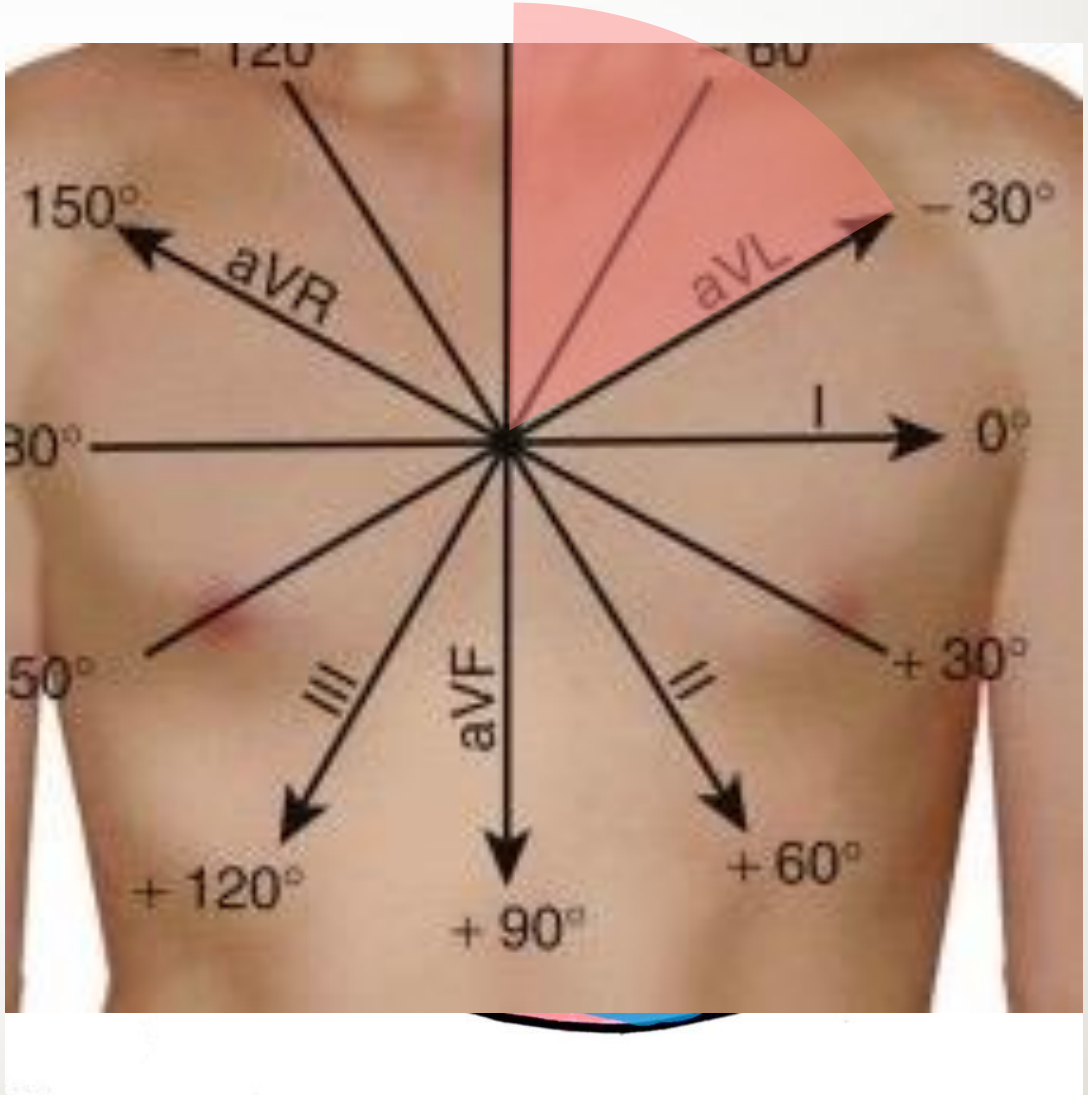
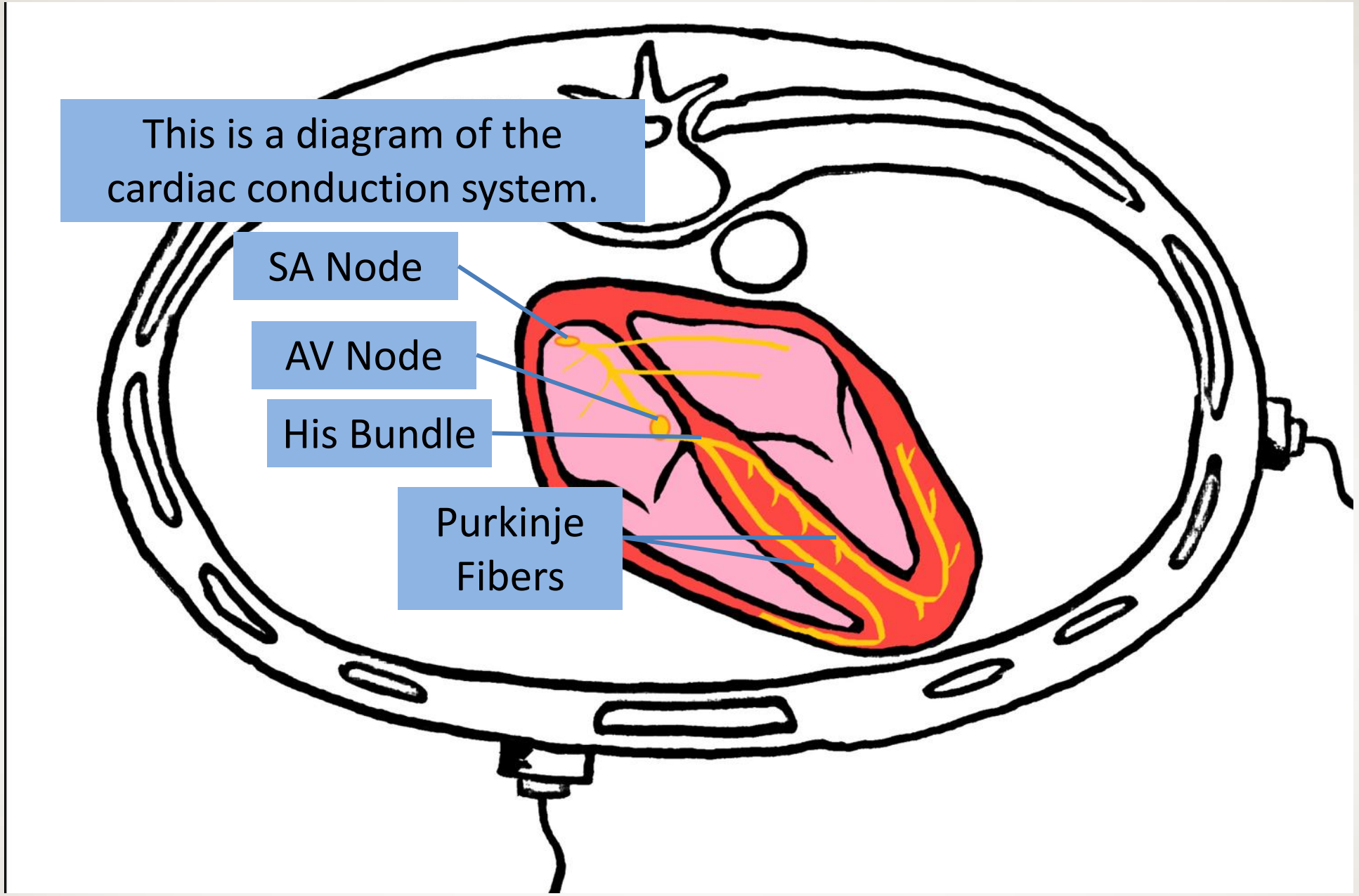


Fascicular Blocks

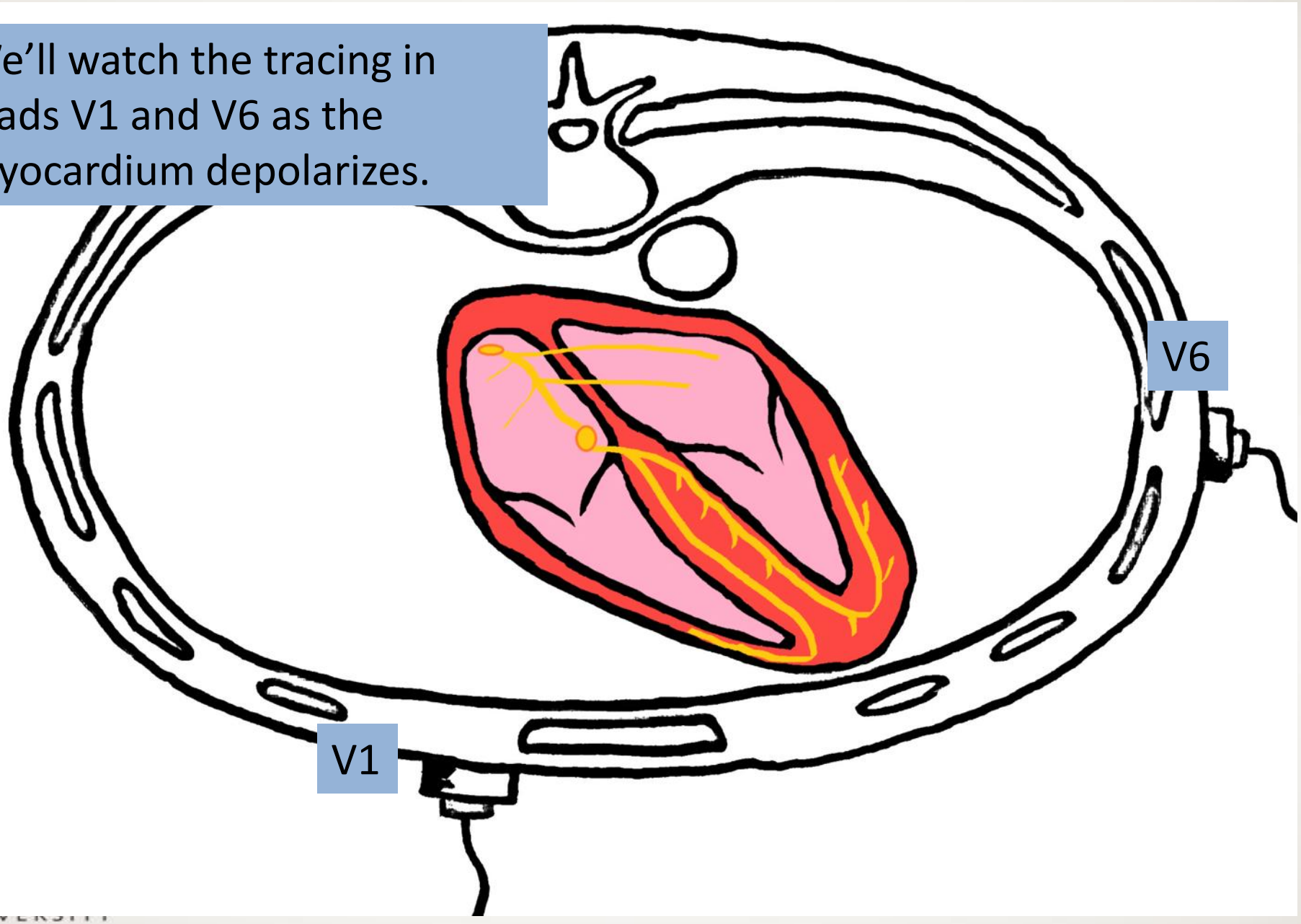
- Now you can imagine how this block changes the axis.
- How is the axis deviated?

Left-Axis Deviation

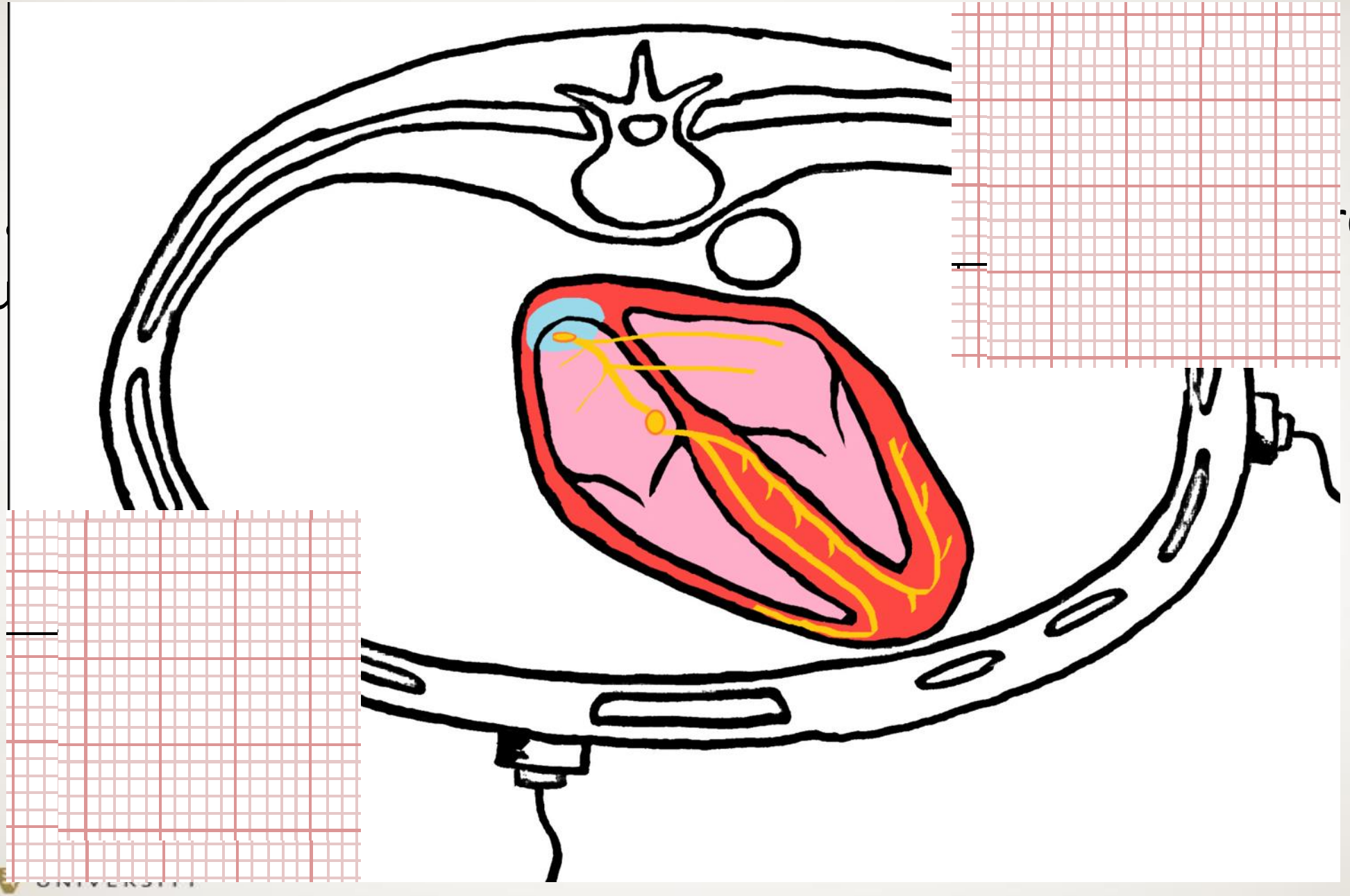



This is a diagram of the cardiac conduction system.
SA Node
AV Node
His Bundle
Purkinje Fibers

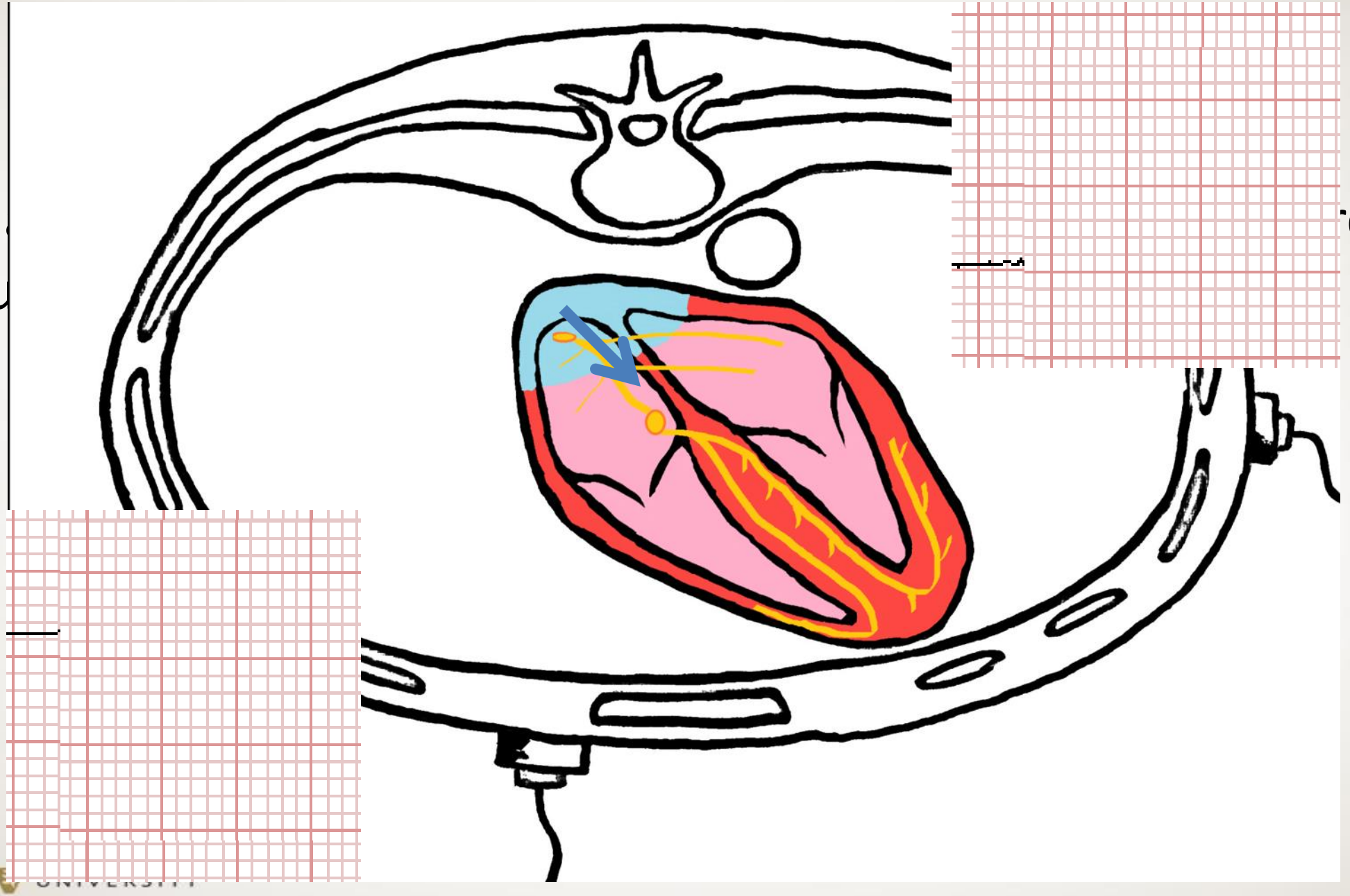
We'll watch the tracing in leads V1 and V6 as the myocardium depolarizes.



- At [illegible] rdiac mu[illegible]

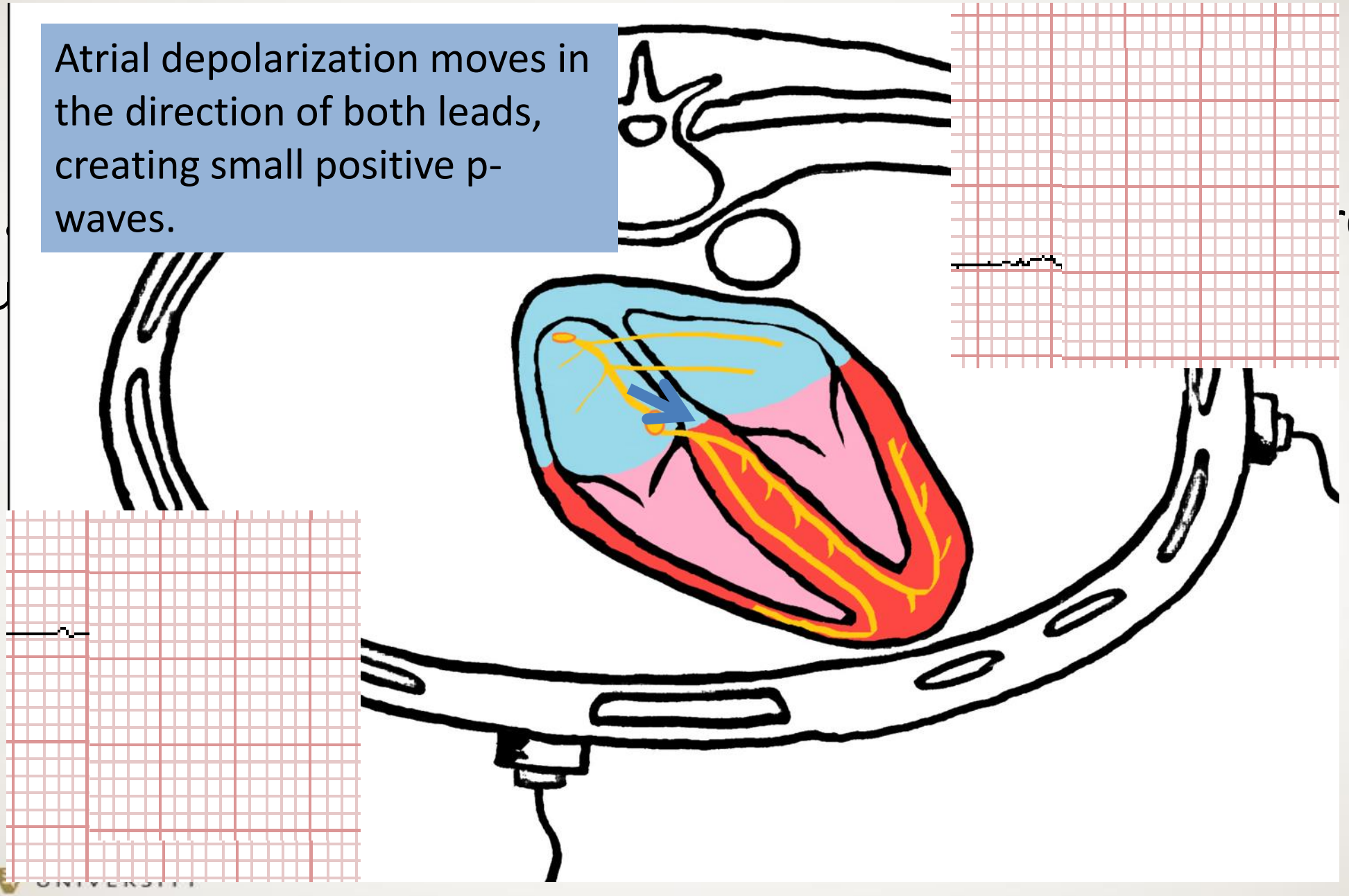


- At rdiac mu



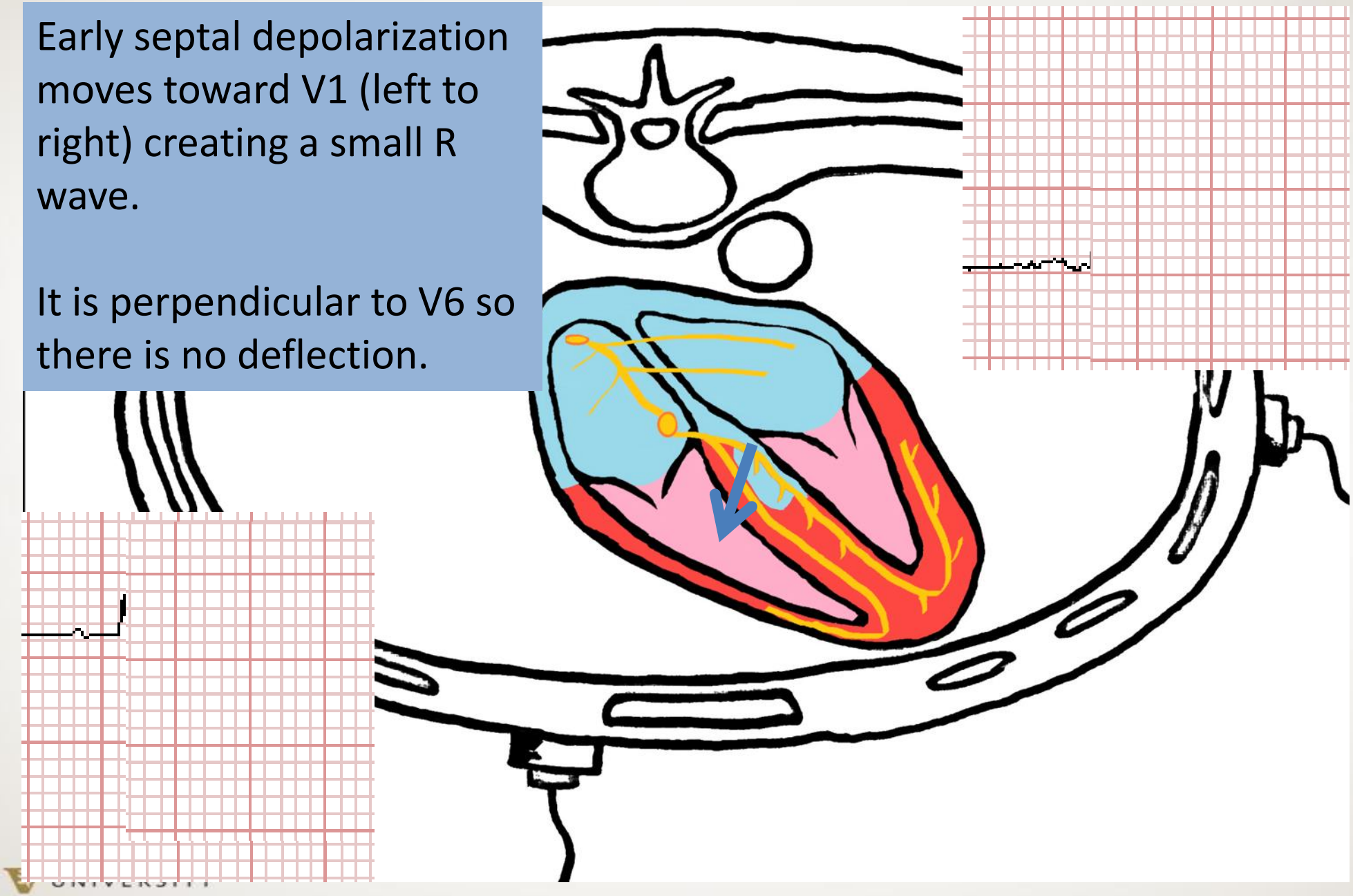
- At rdiac mu

Atrial depolarization moves in the direction of both leads, creating small positive p-waves.



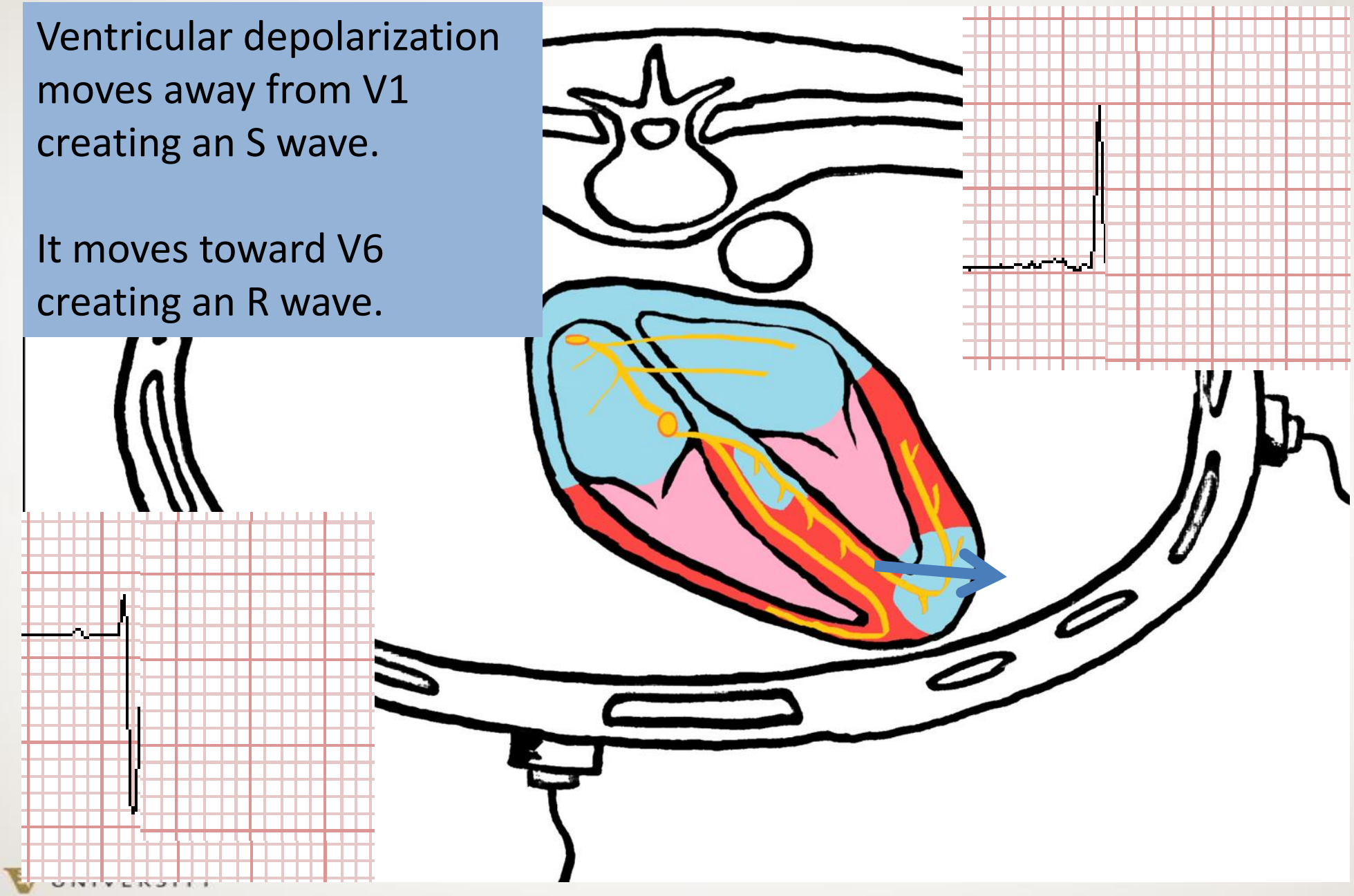
Early septal depolarization moves toward V1 (left to right) creating a small R wave.

It is perpendicular to V6 so there is no deflection.



Ventricular depolarization moves away from V1 creating an S wave.

It moves toward V6 creating an R wave.



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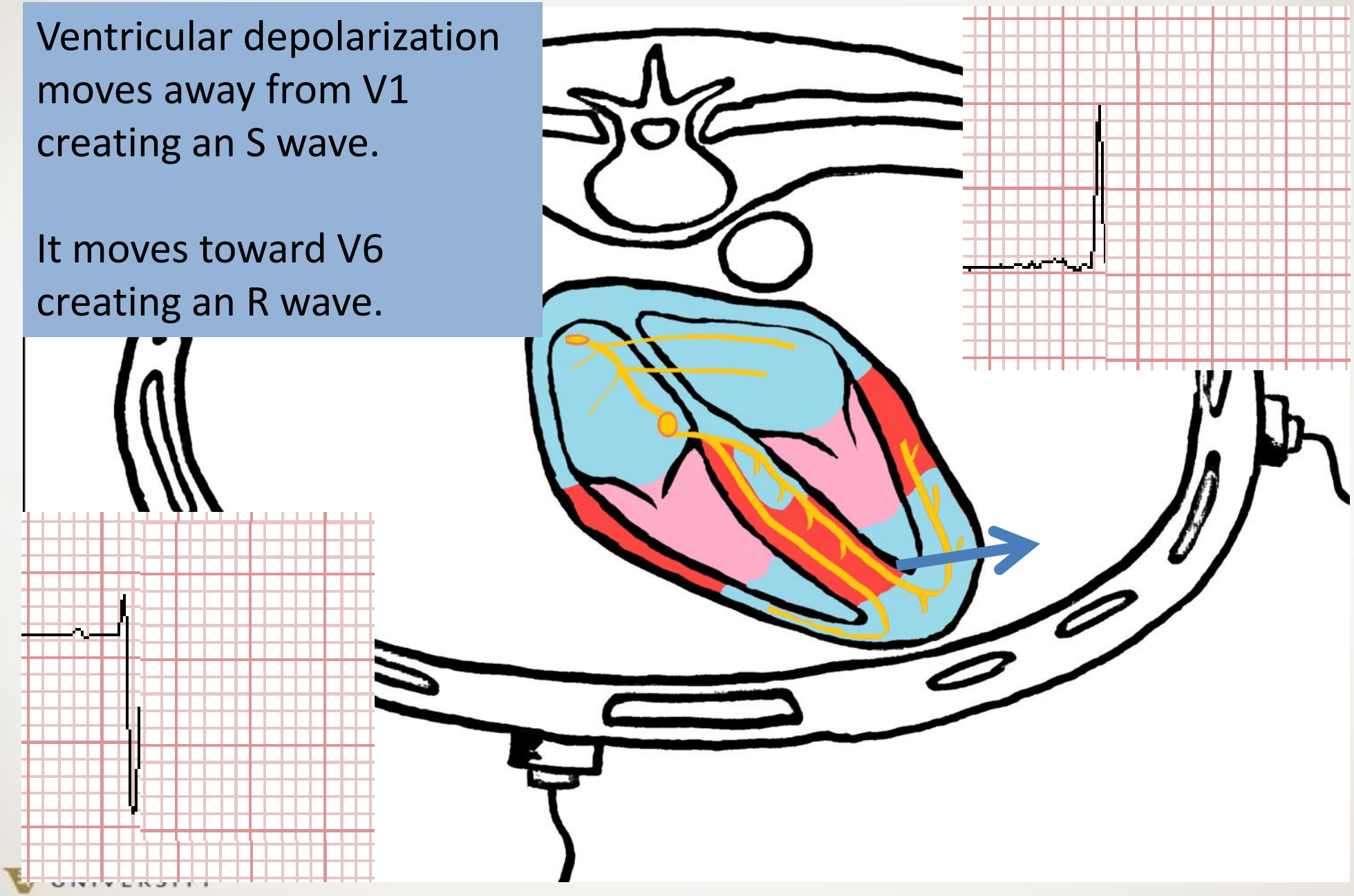

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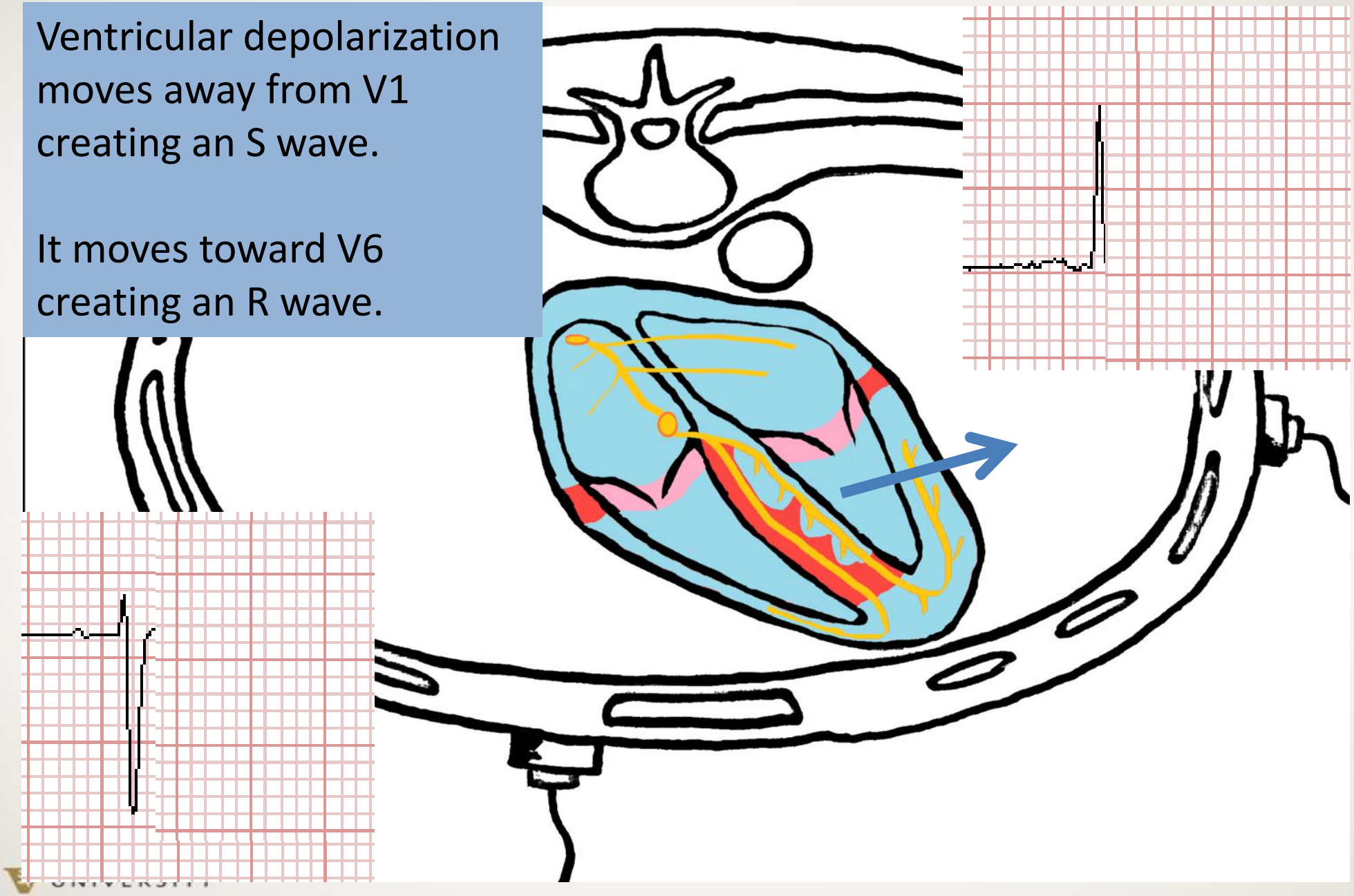

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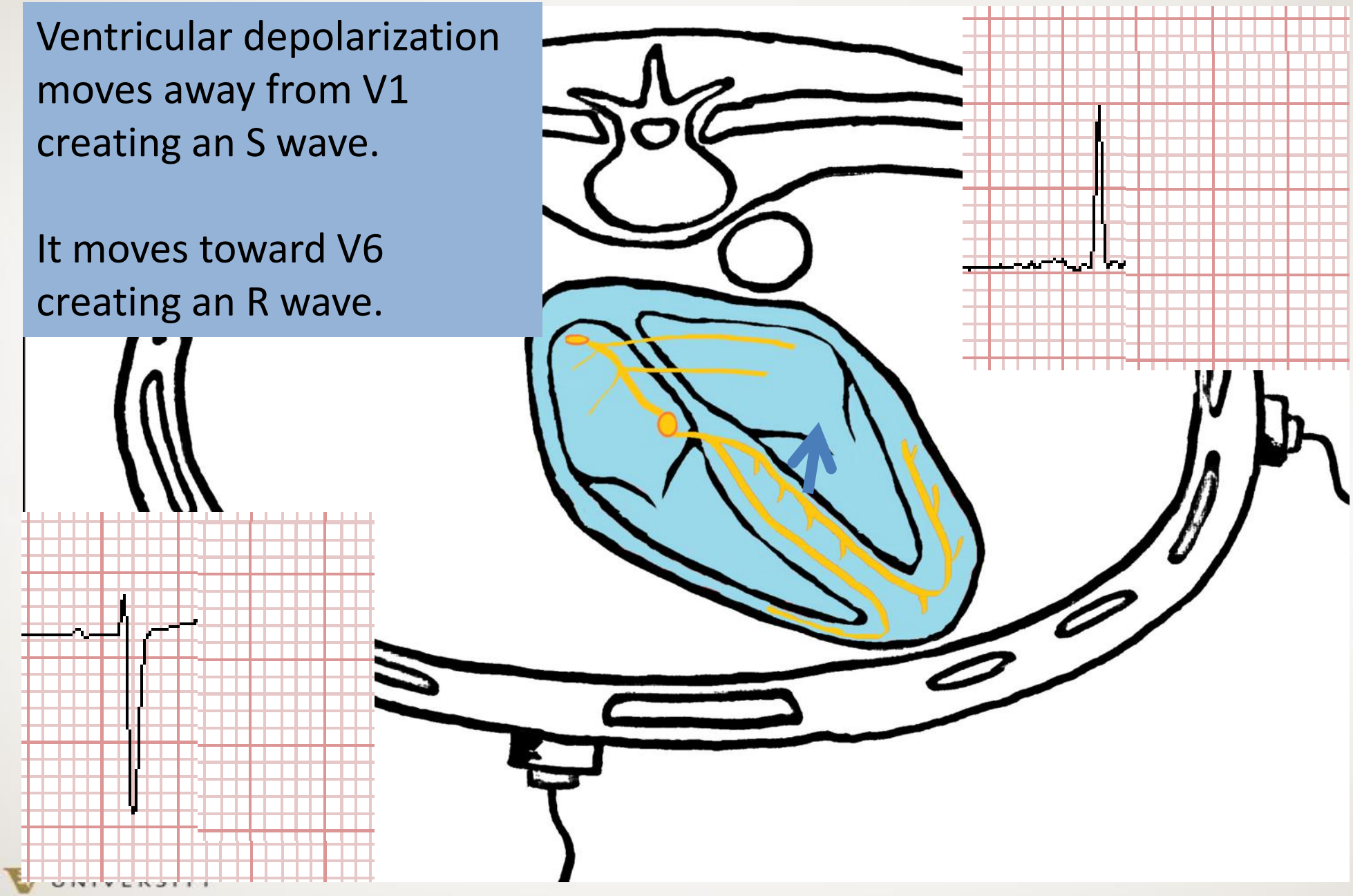
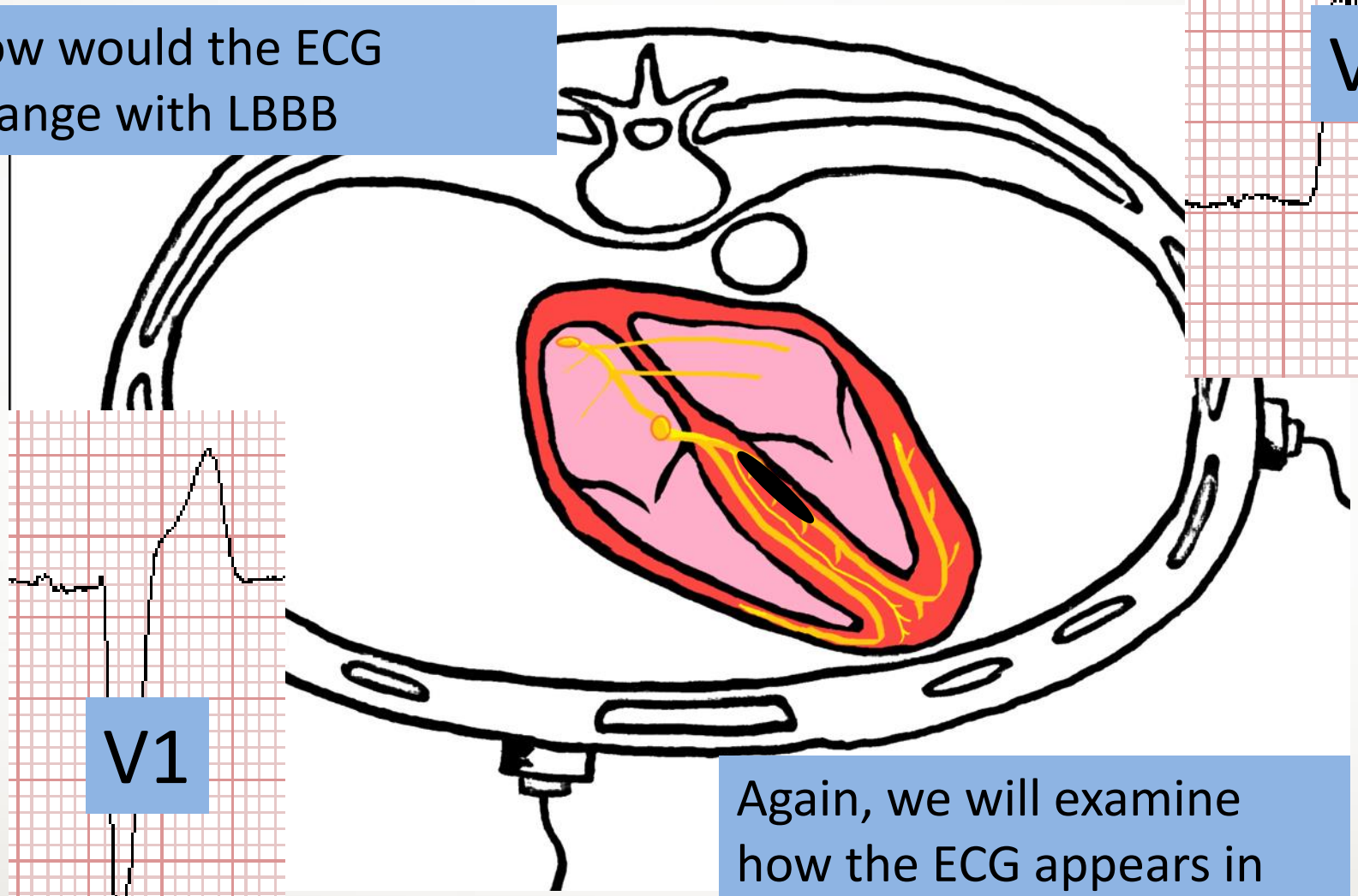
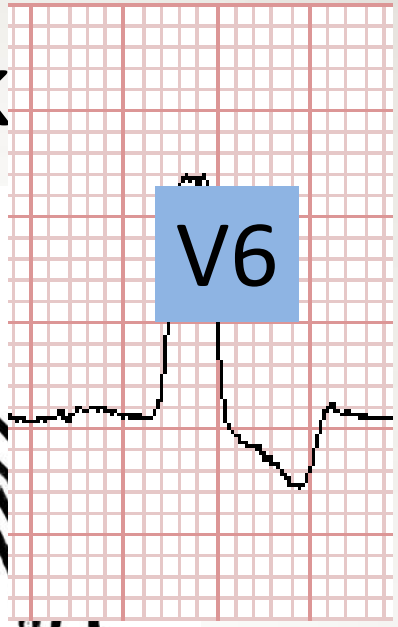


Left Bundle Branch Block

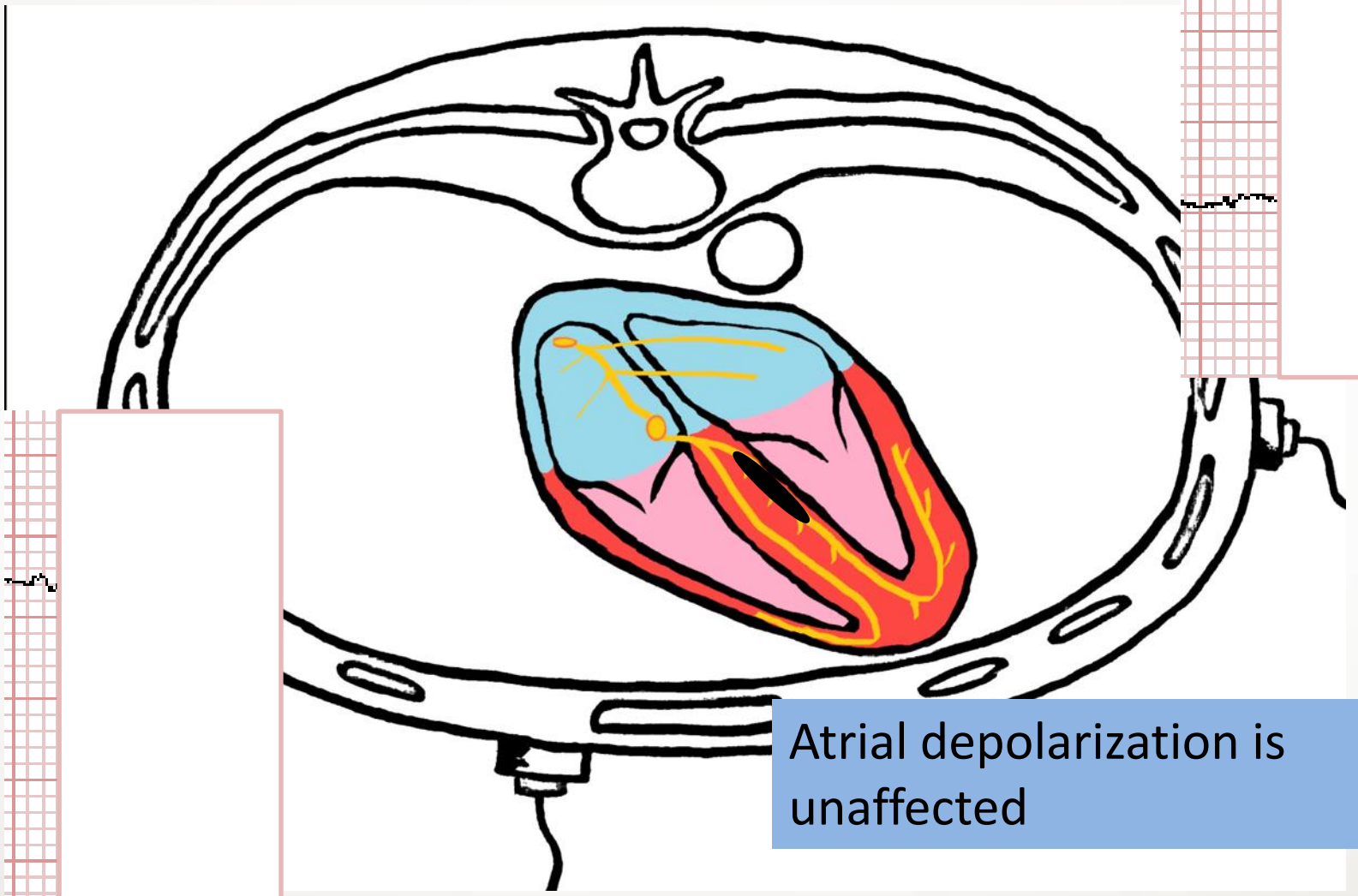
How would the ECG change with LBBB





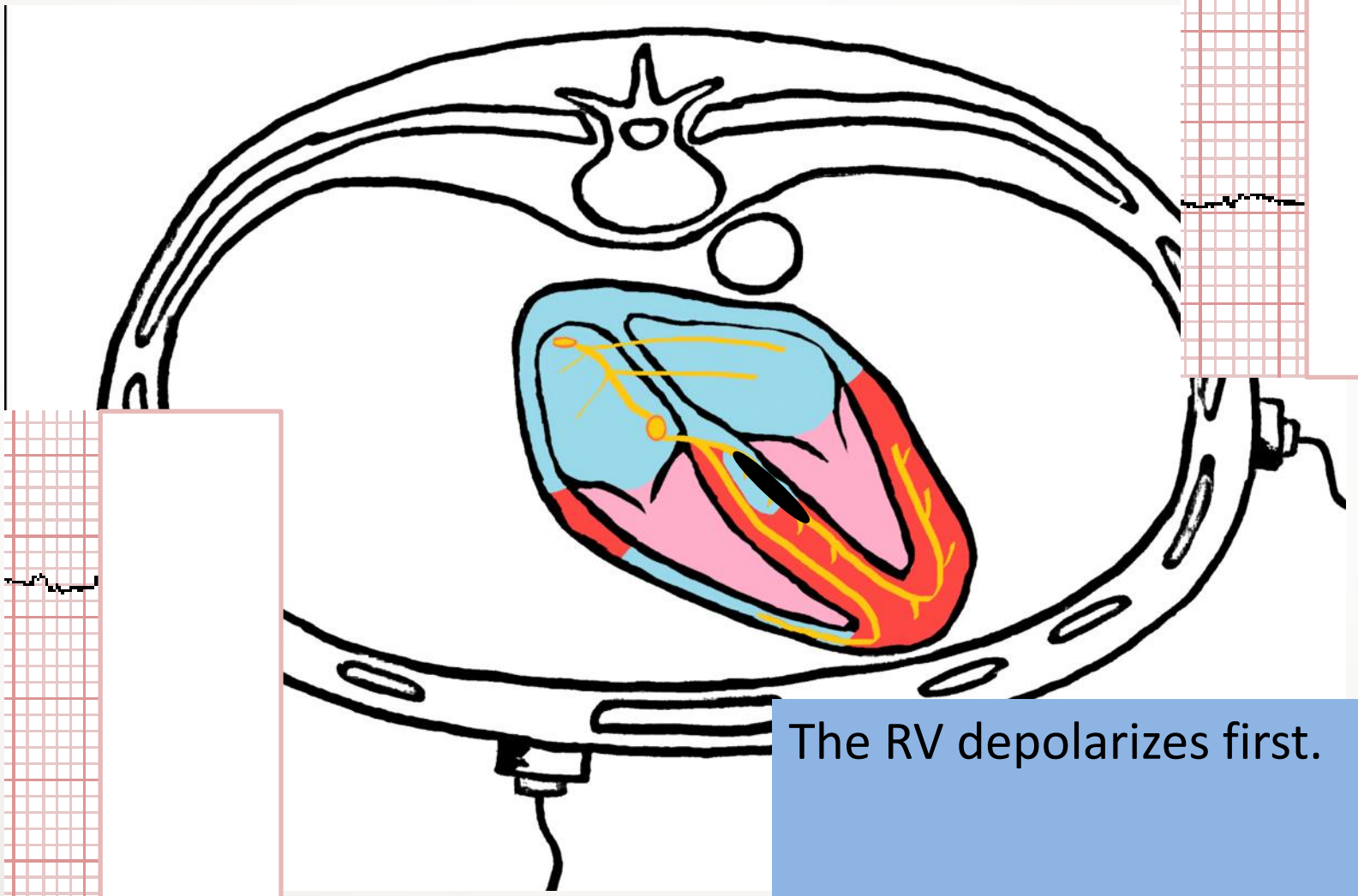
Again, we will examine how the ECG appears in V1 and V6.

Left Bundle Branch Block



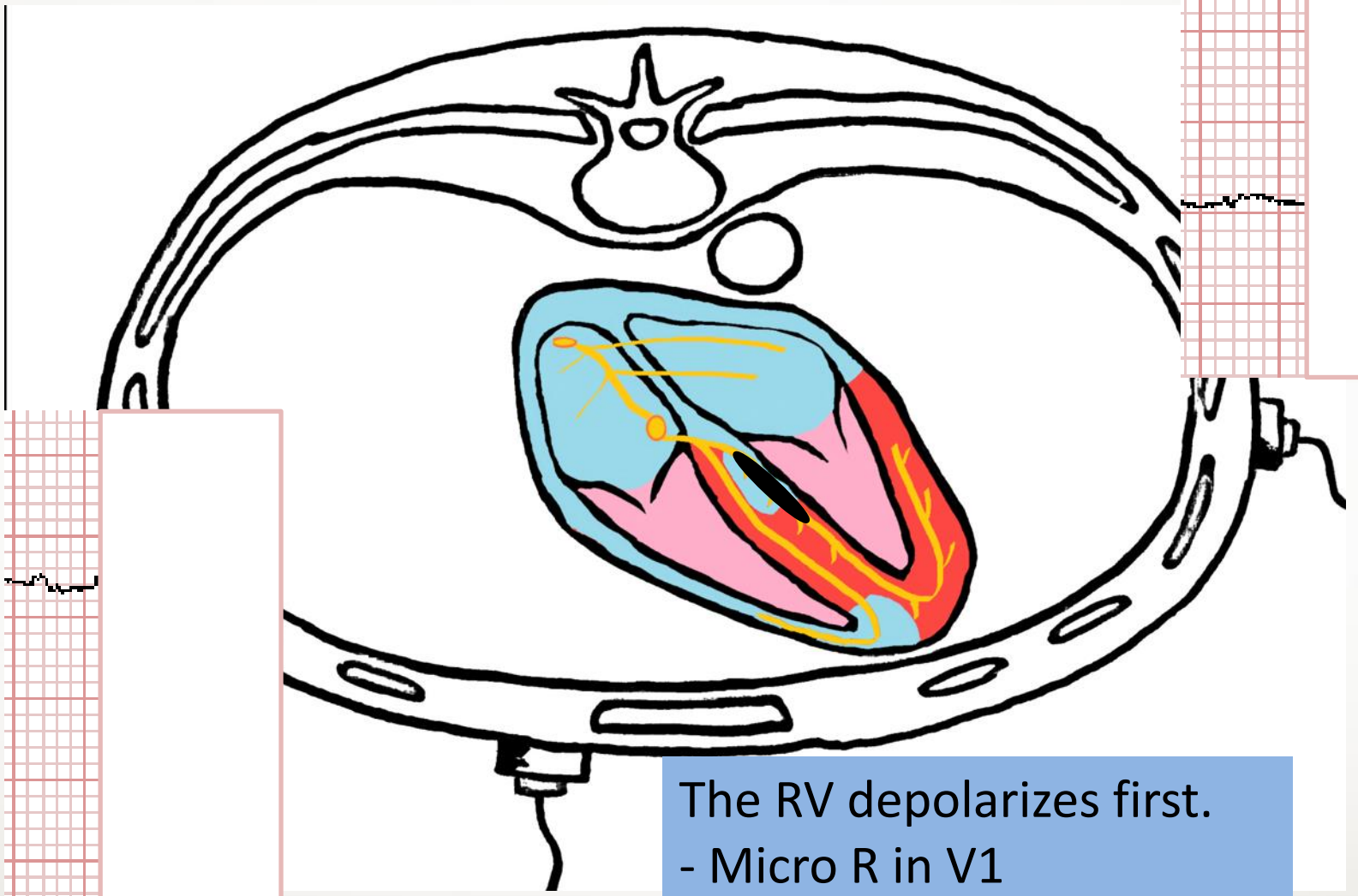
Atrial depolarization is unaffected

Left Bundle Branch Block



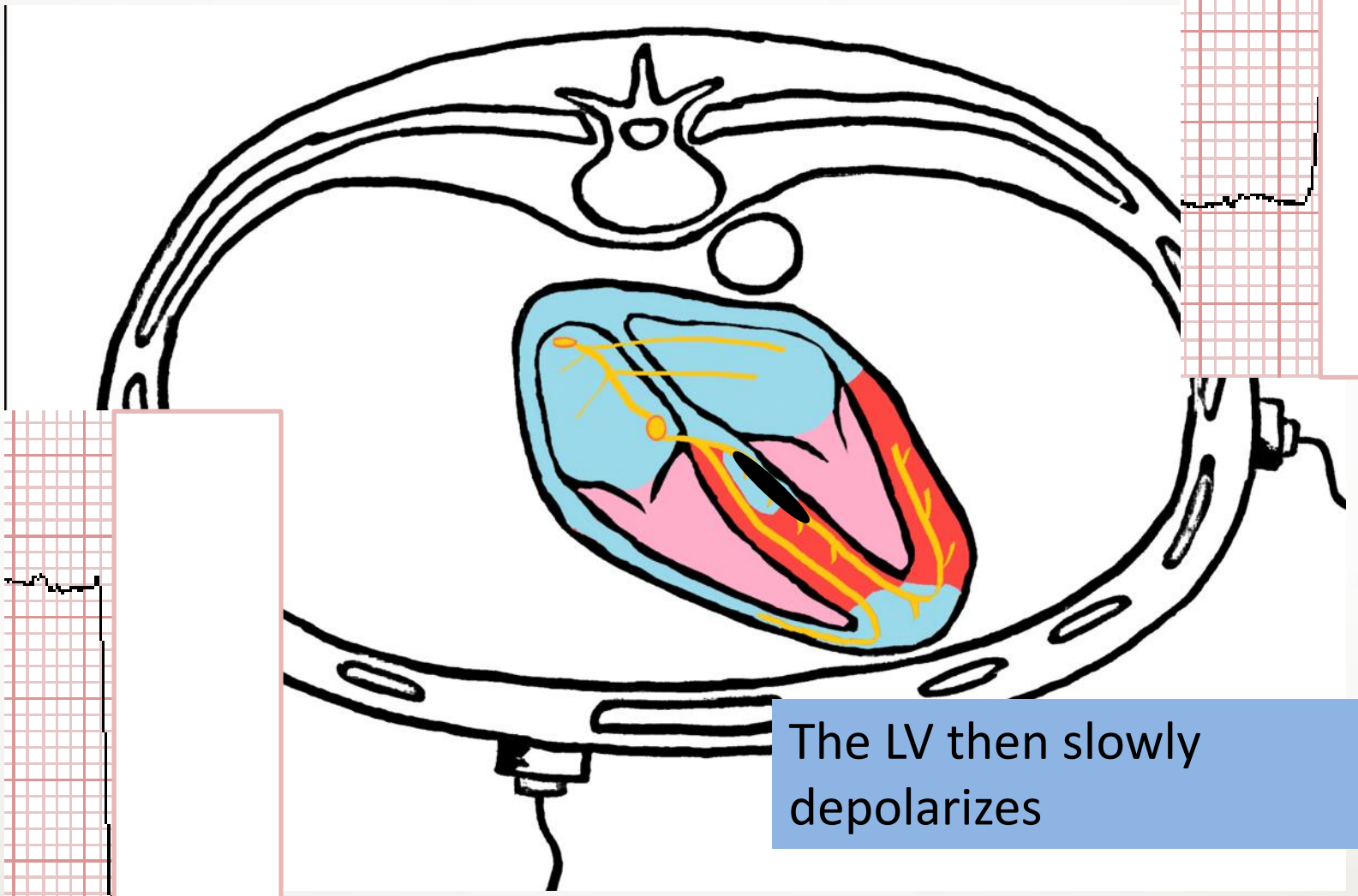
The RV depolarizes first.

Left Bundle Branch Block



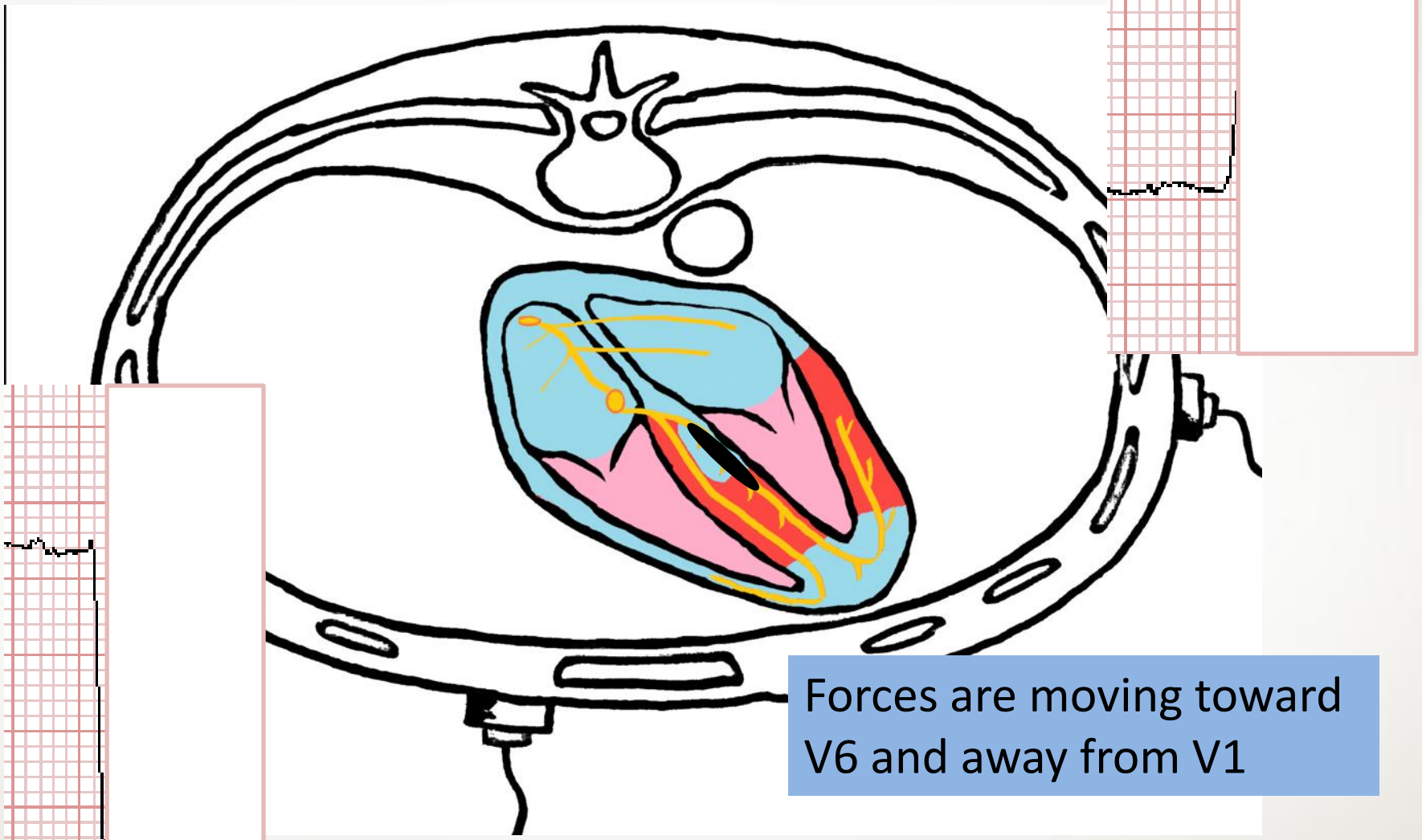
The RV depolarizes first.
- Micro R in V1
- Micro S in V6

Left Bundle Branch Block



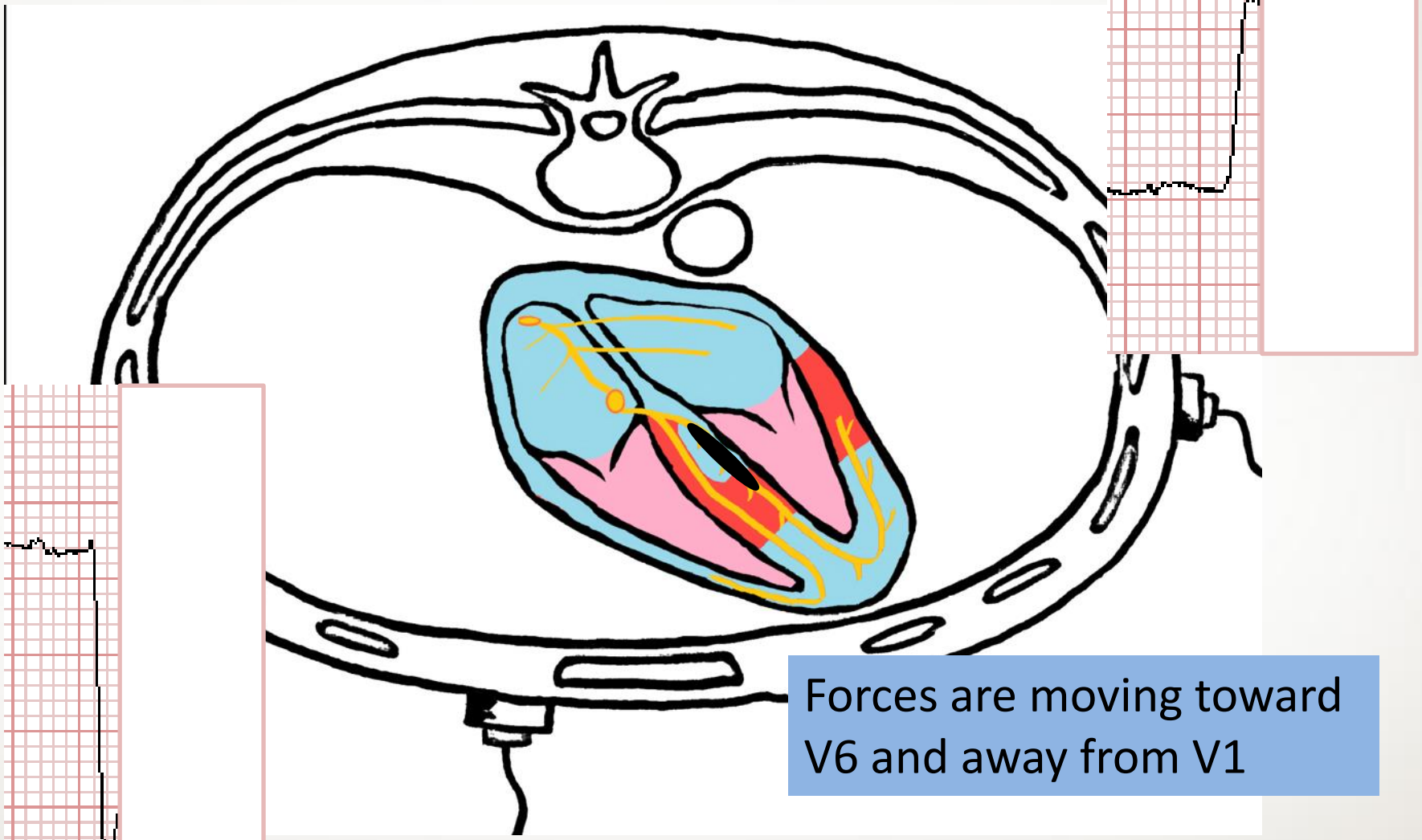
The LV then slowly depolarizes

Left Bundle Branch Block



Forces are moving toward V6 and away from V1

Left Bundle Branch Block



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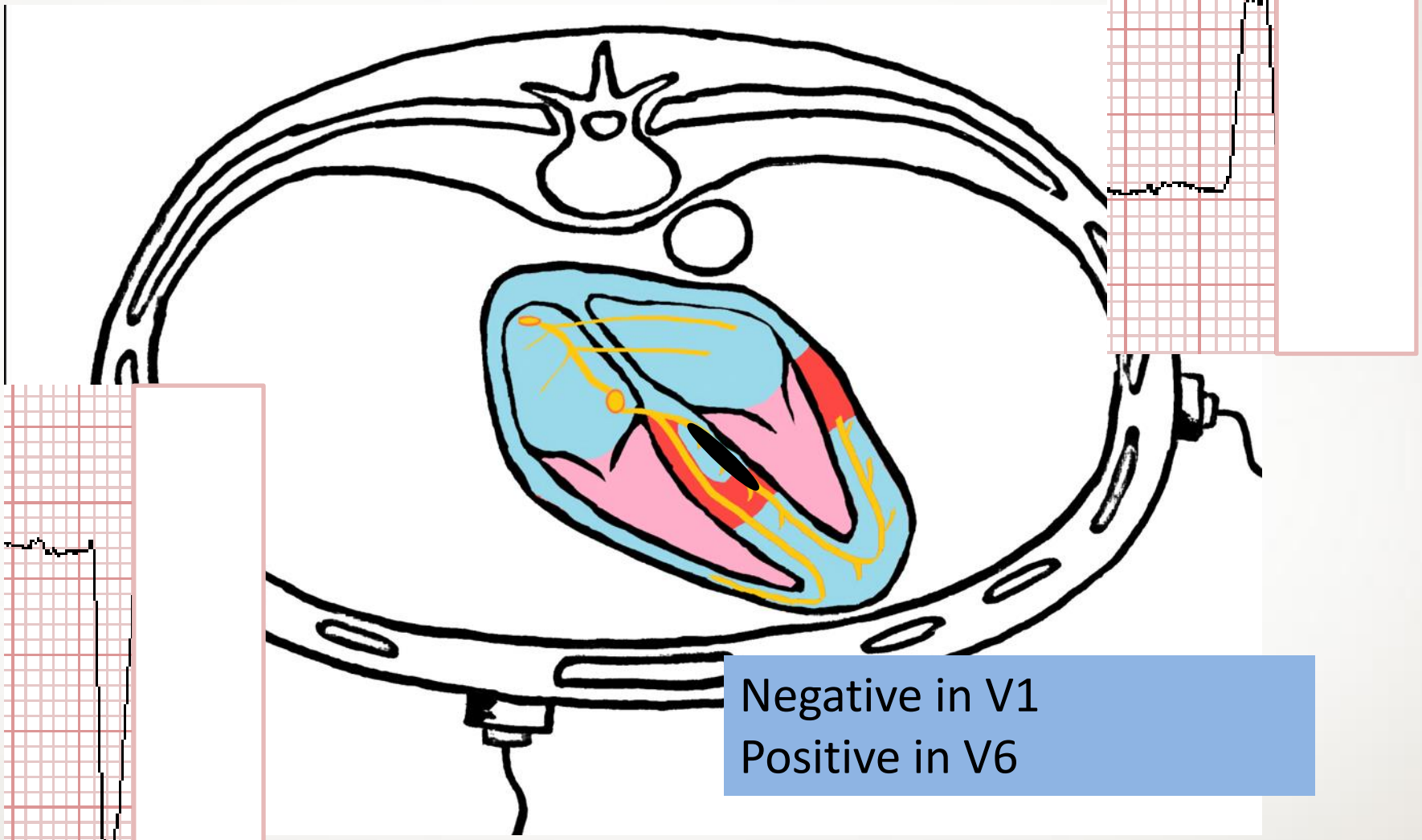
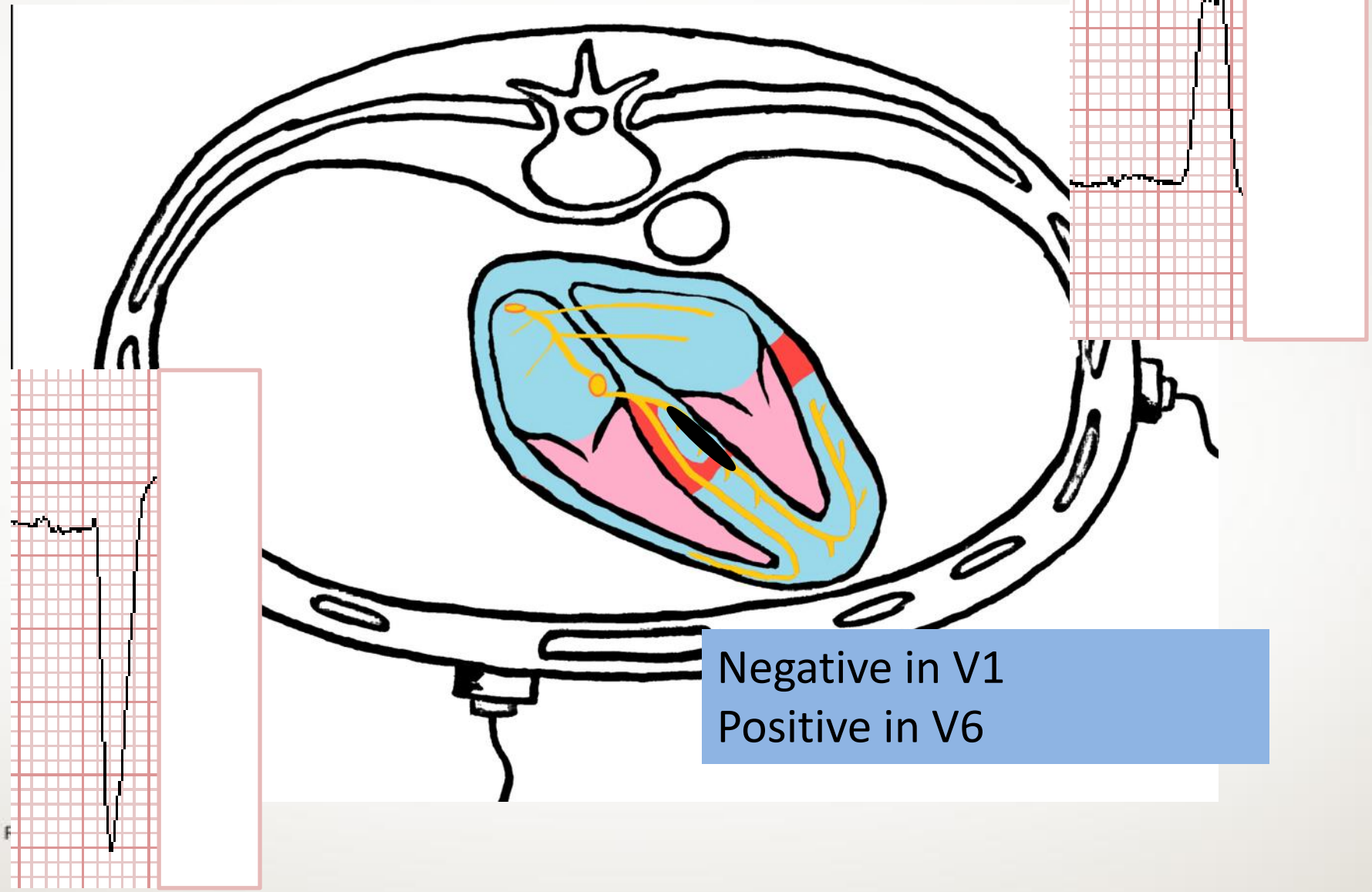
Left Bundle Branch Block



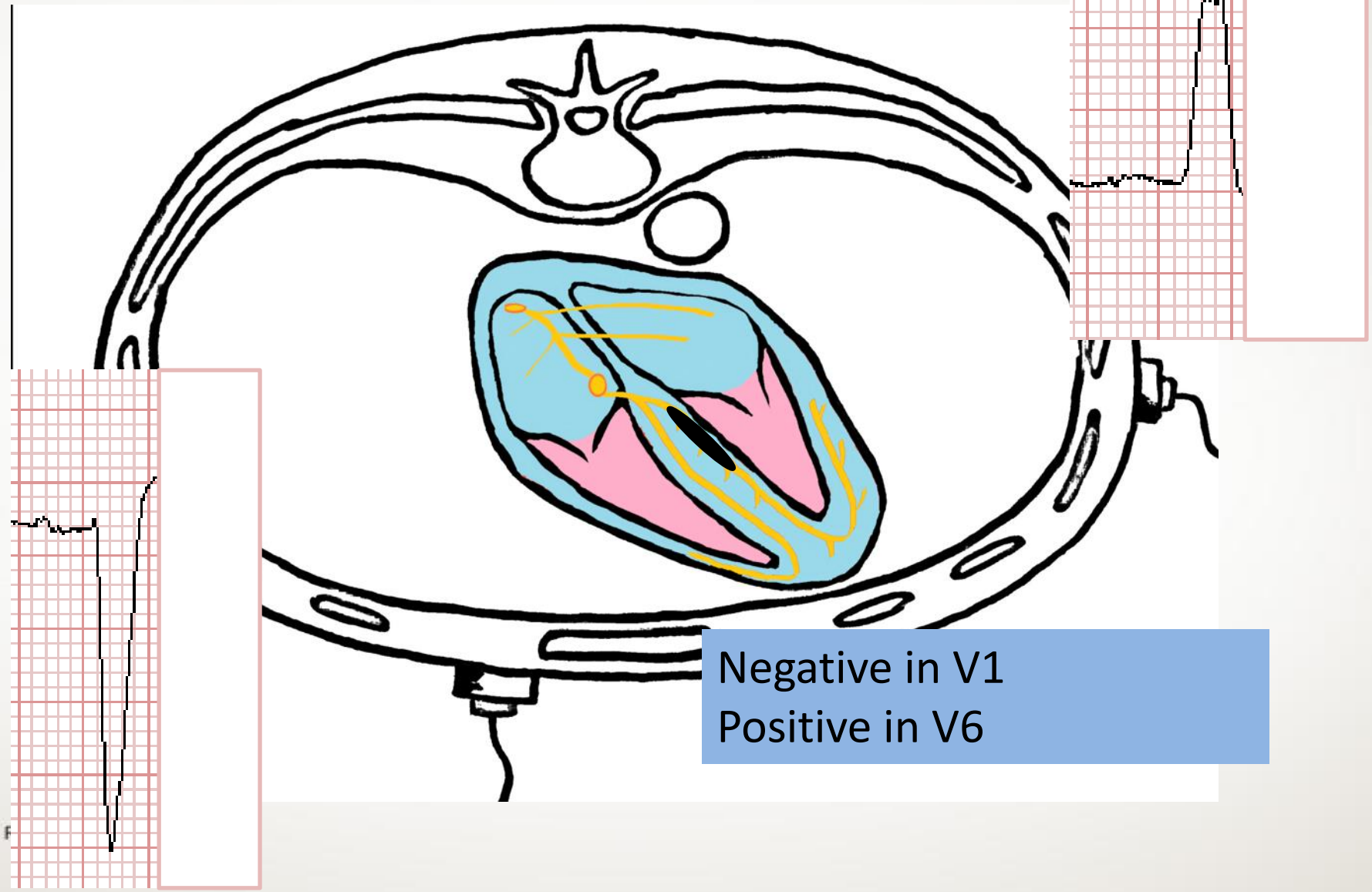
Negative in V1
Positive in V6

Left Bundle Branch Block



Negative in V1
Positive in V6

Left Bundle Branch Block

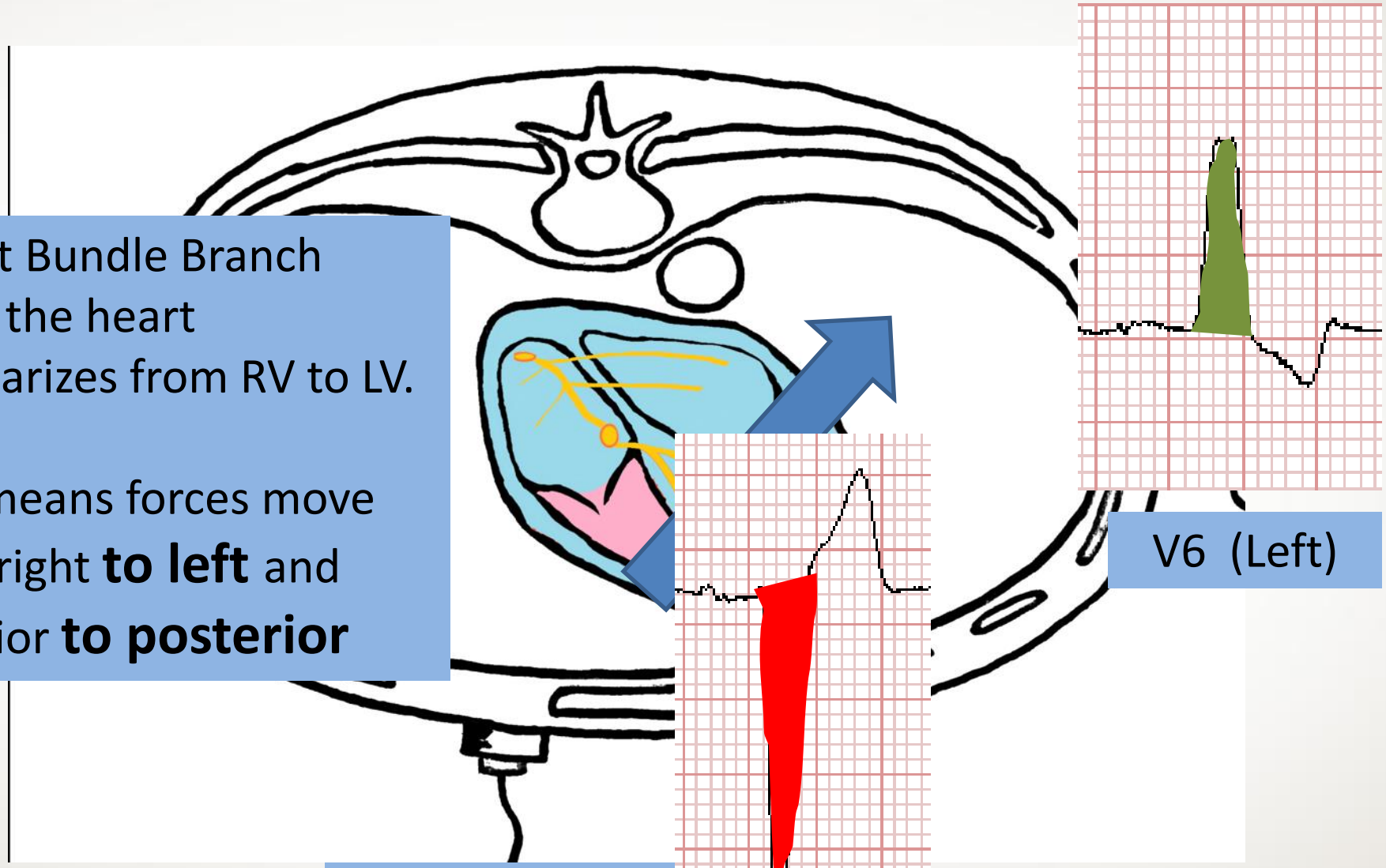


Negative in V1
Positive in V6

Left Bundle Branch Block

In Left Bundle Branch Block the heart depolarizes from RV to LV.

This means forces move from right **to left** and anterior **to posterior**

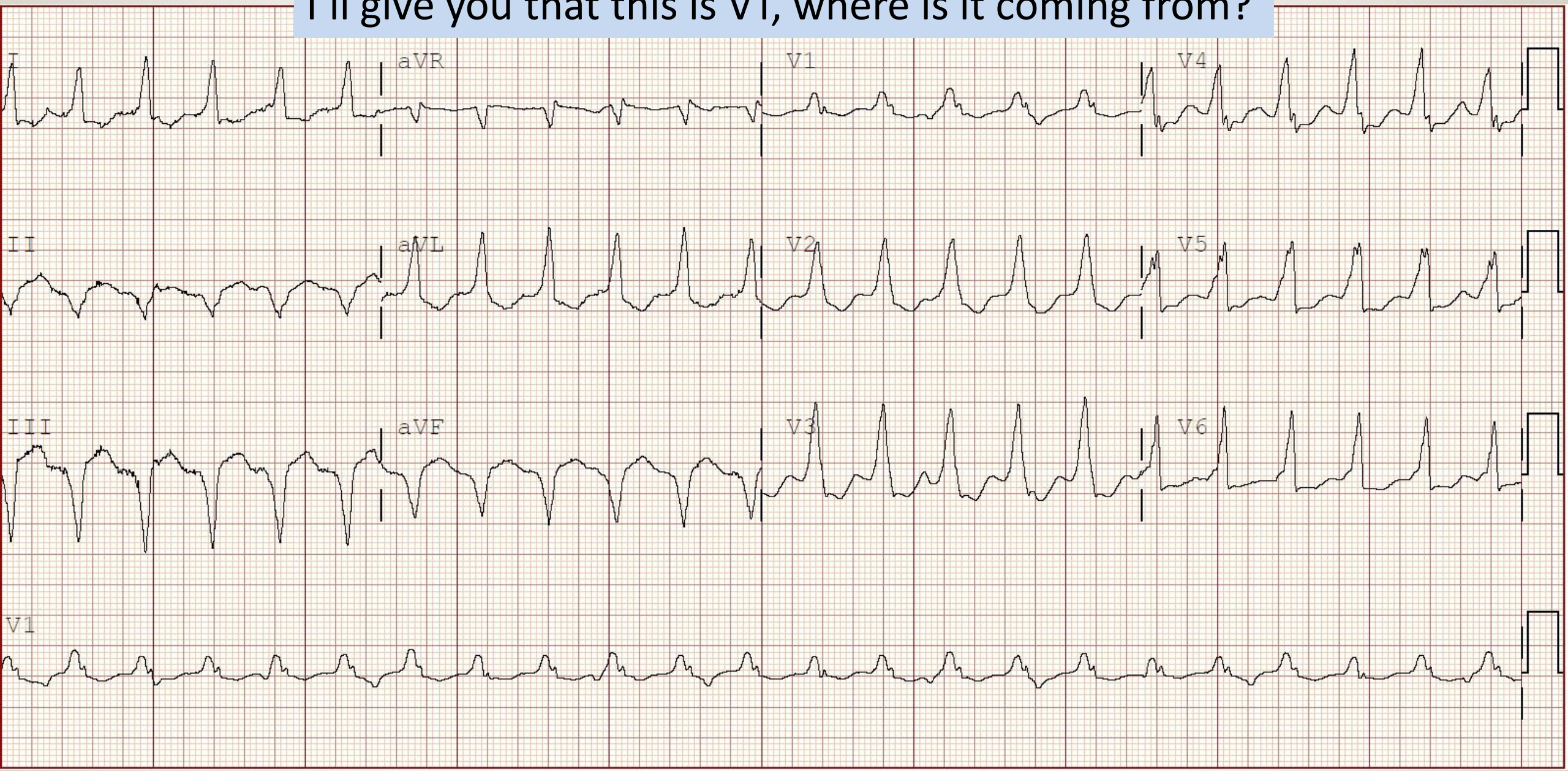


V6 (Left)

V1 (Anterior)

Let's try applying vectors a bit

I'll give you that this is VT, where is it coming from?



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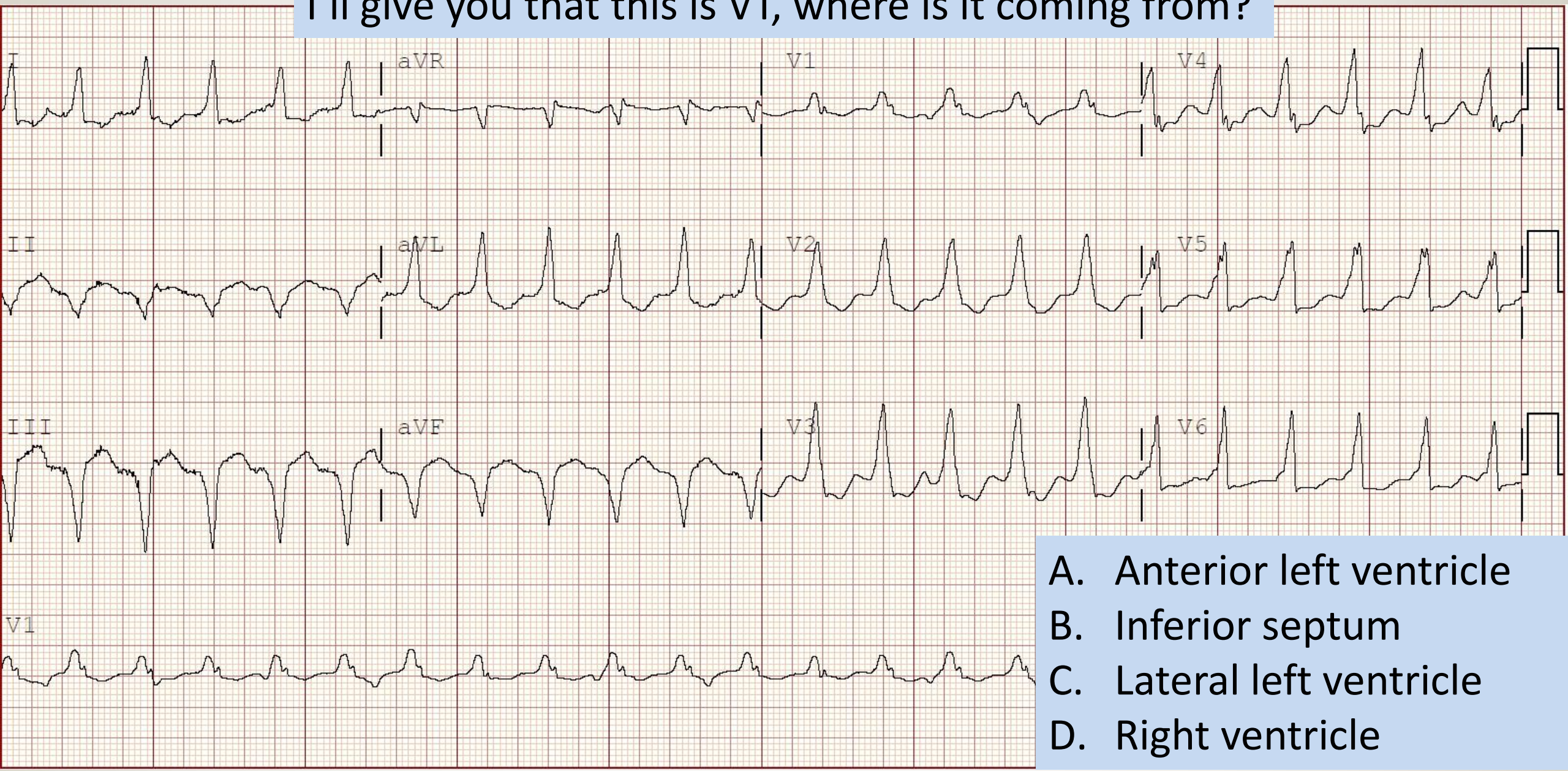

A. Anterior left ventricle
B. Inferior septum
C. Lateral left ventricle
D. Right ventricle

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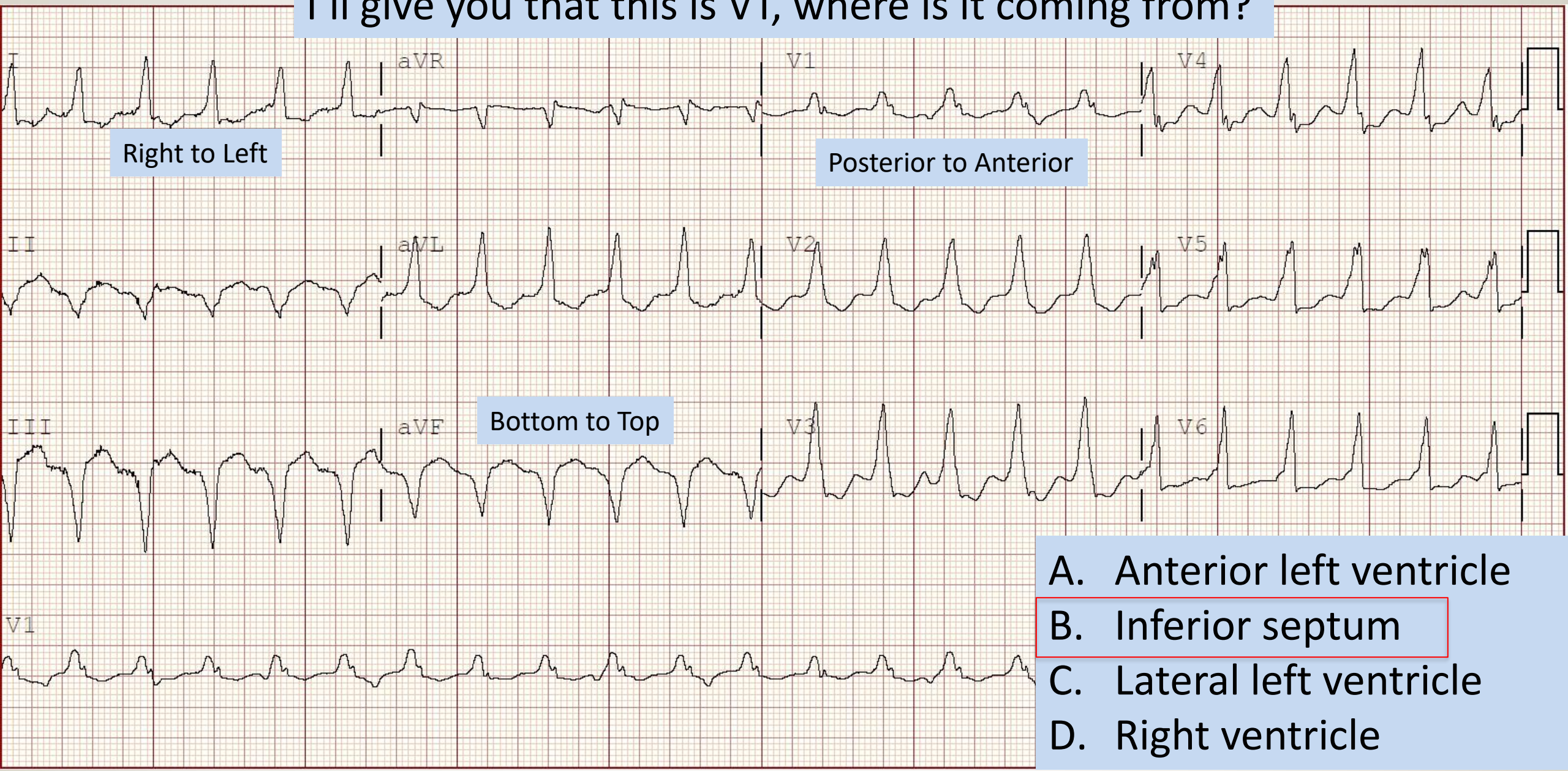
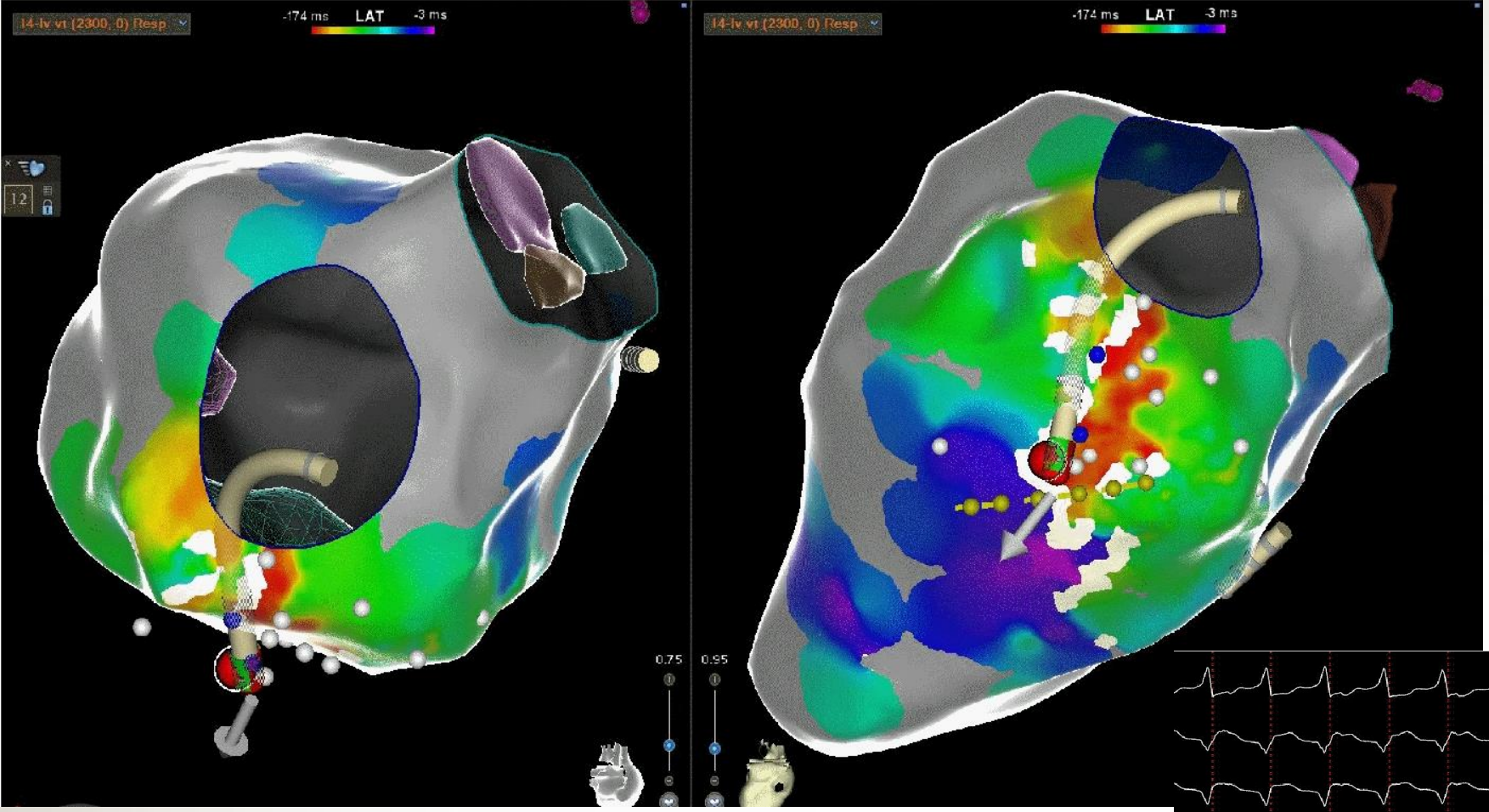


A. Anterior left ventricle
B. Inferior septum
C. Lateral left ventricle
D. Right ventricle



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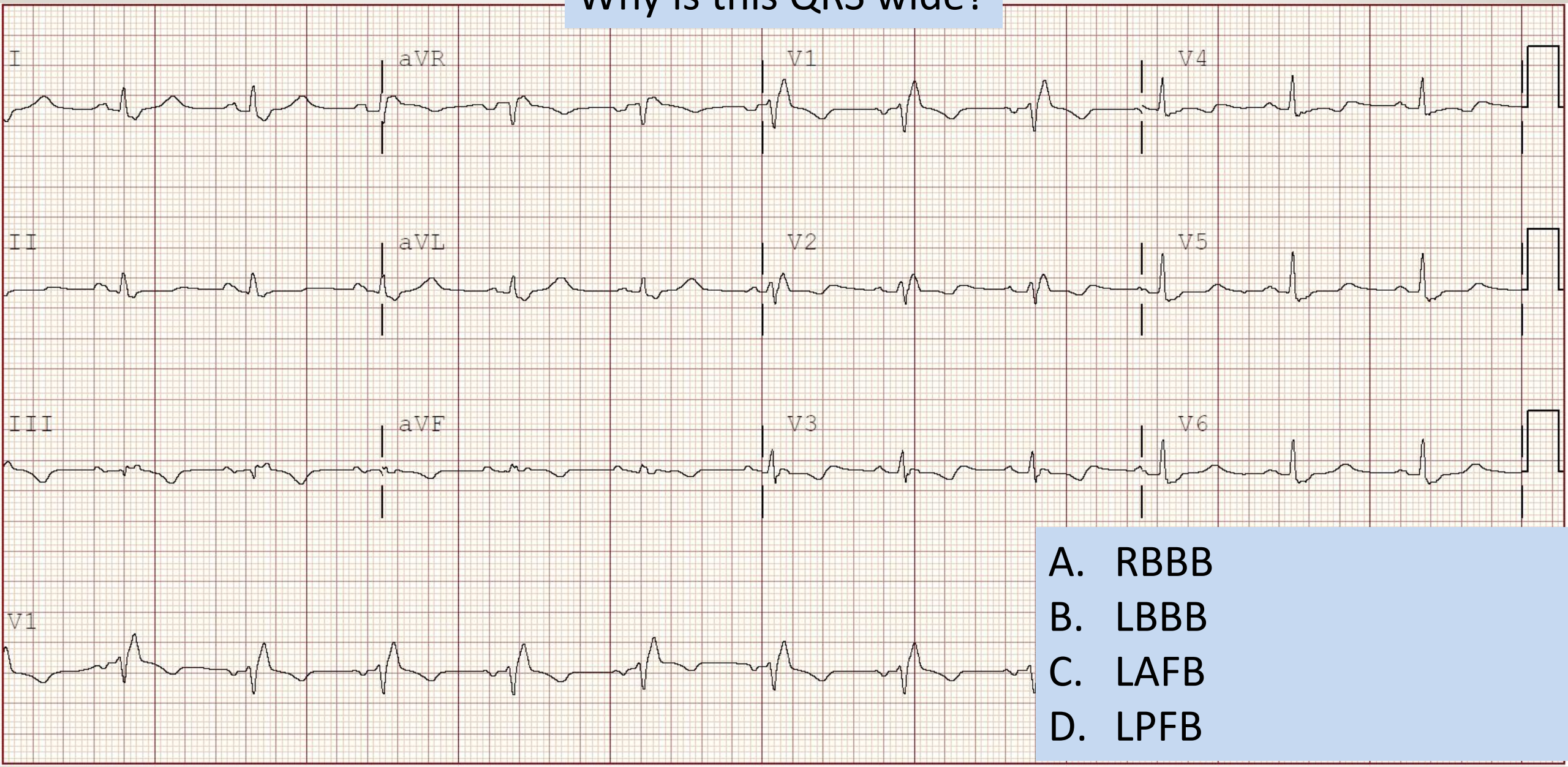
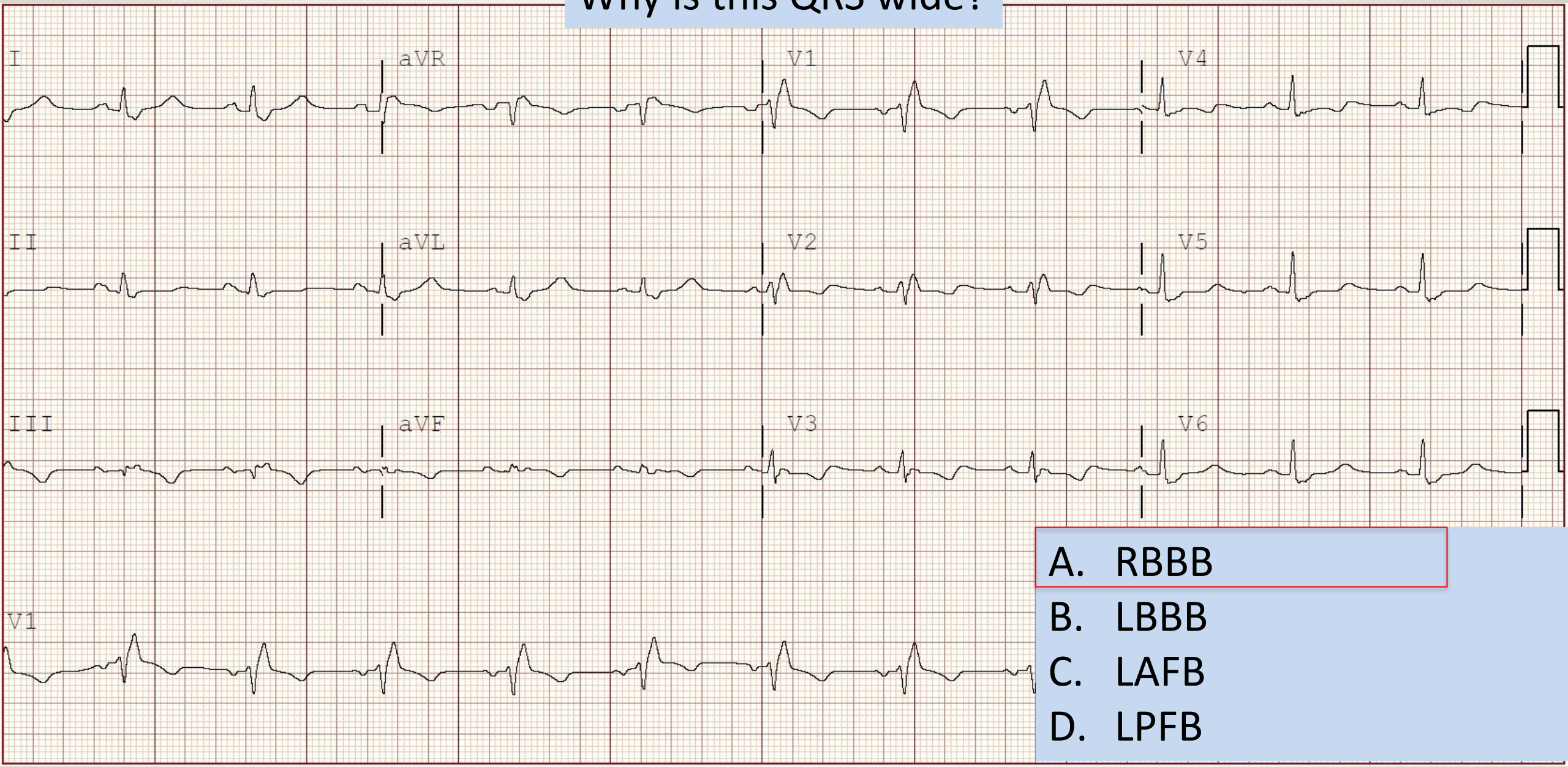
Why is this QRS wide?



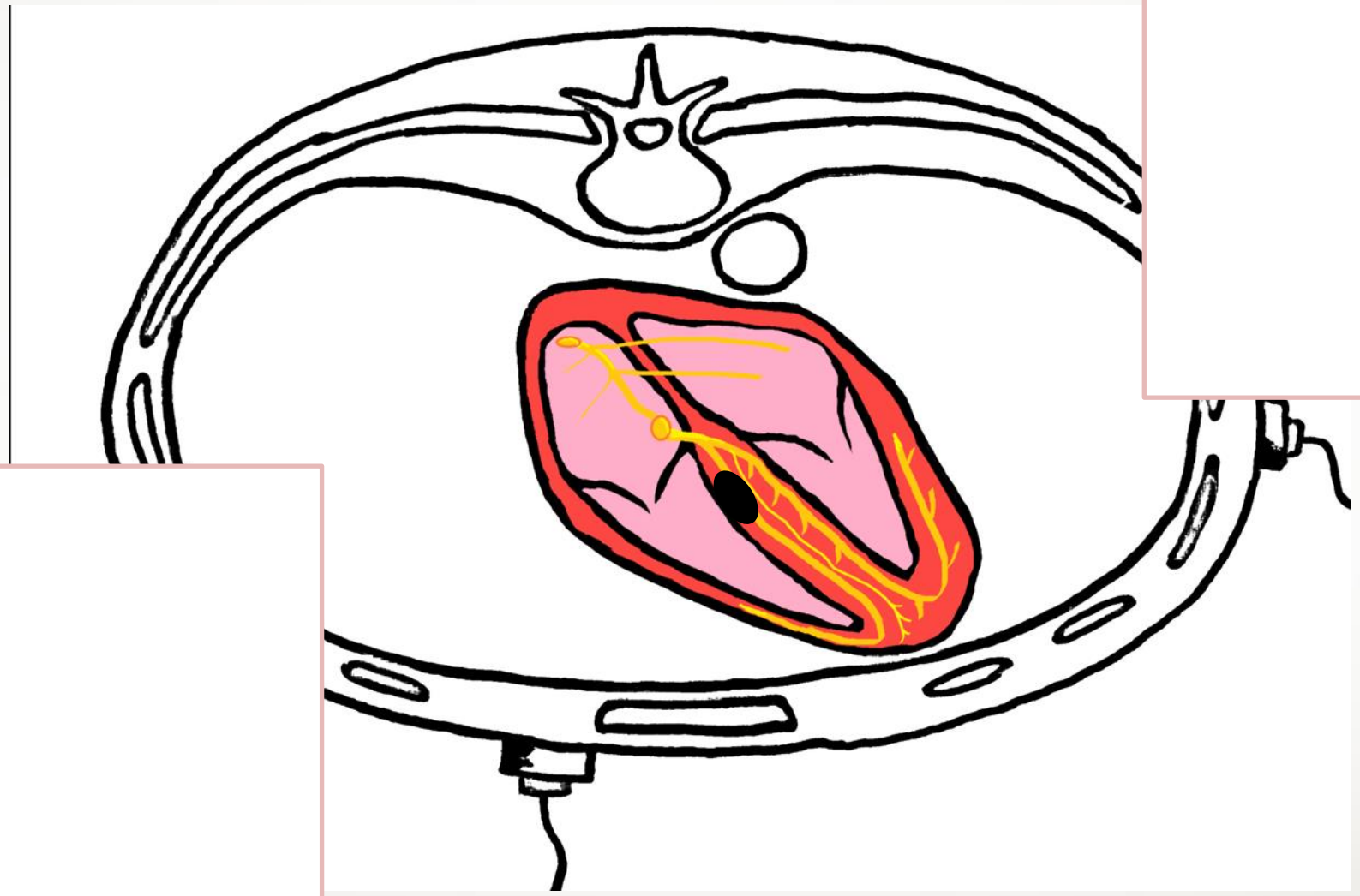
A. RBBB
B. LBBB
C. LAFB
D. LPFB

Why is this QRS wide?

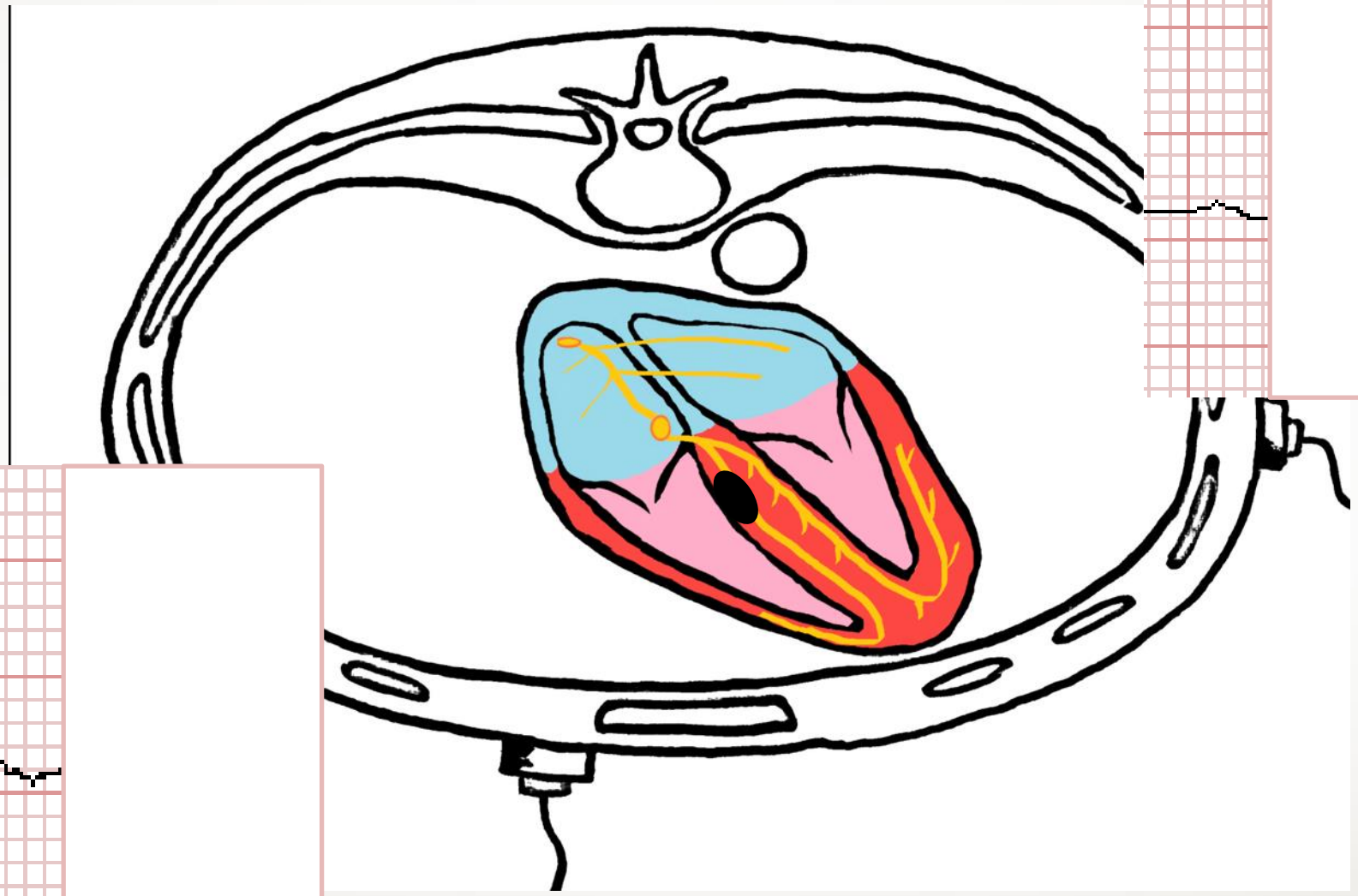


A. RBBB
B. LBBB
C. LAFB
D. LPFB

Right Bundle Branch Block



Right Bundle Branch Block



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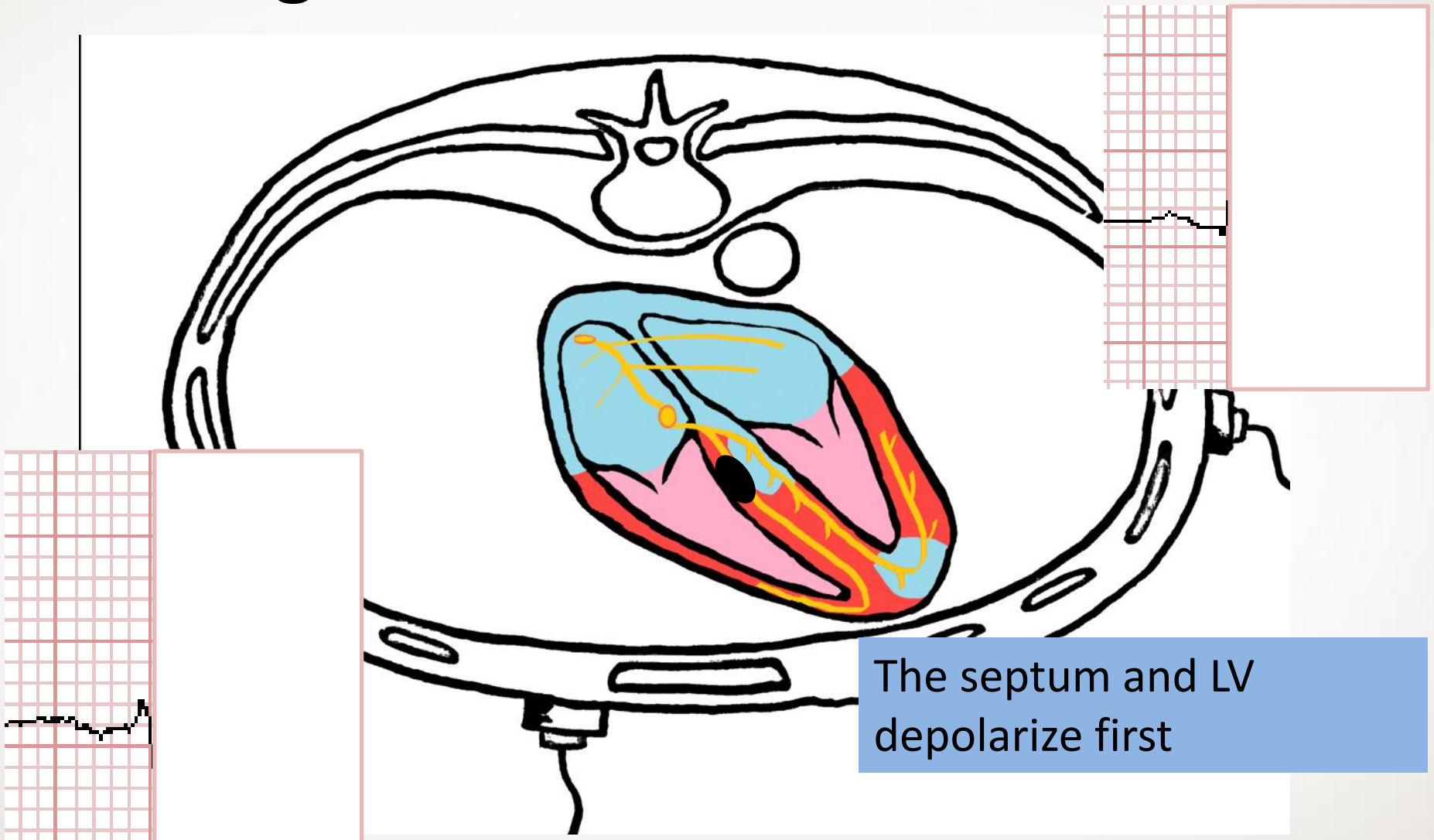
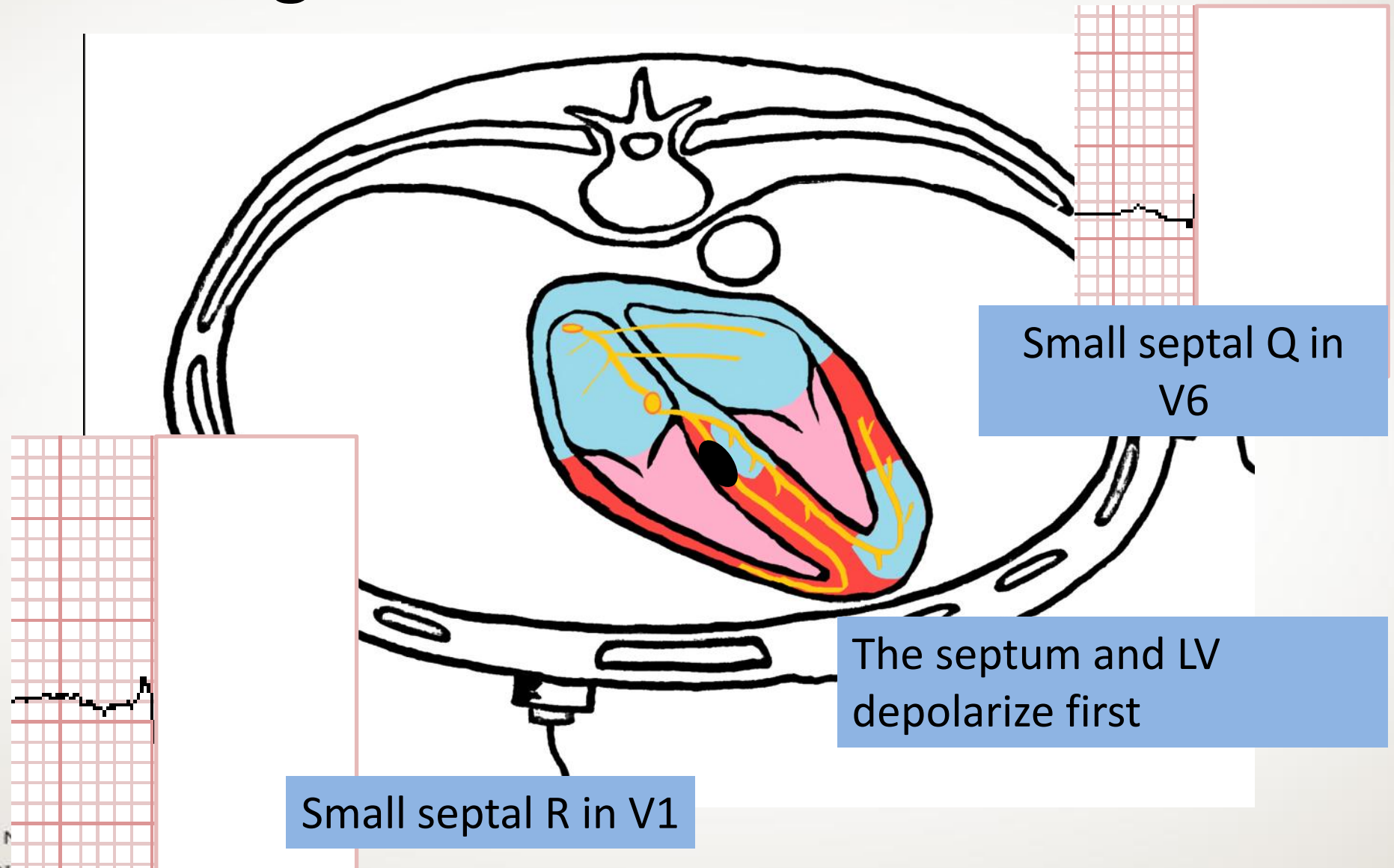
Right Bundle Branch Block



The septum and LV depolarize first

Right Bundle Branch Block

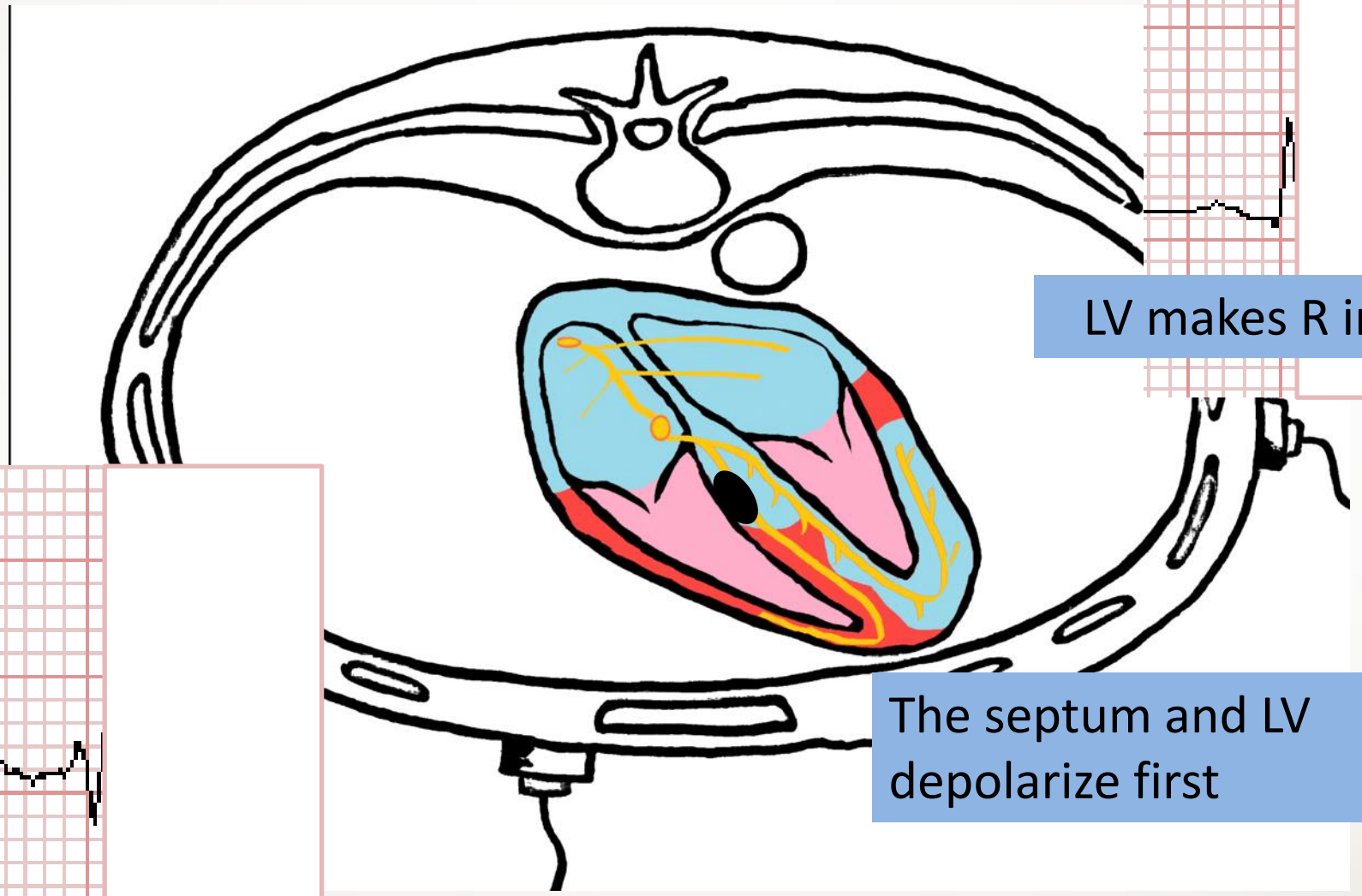


Small septal Q in V6

The septum and LV depolarize first

Small septal R in V1

Right Bundle Branch Block

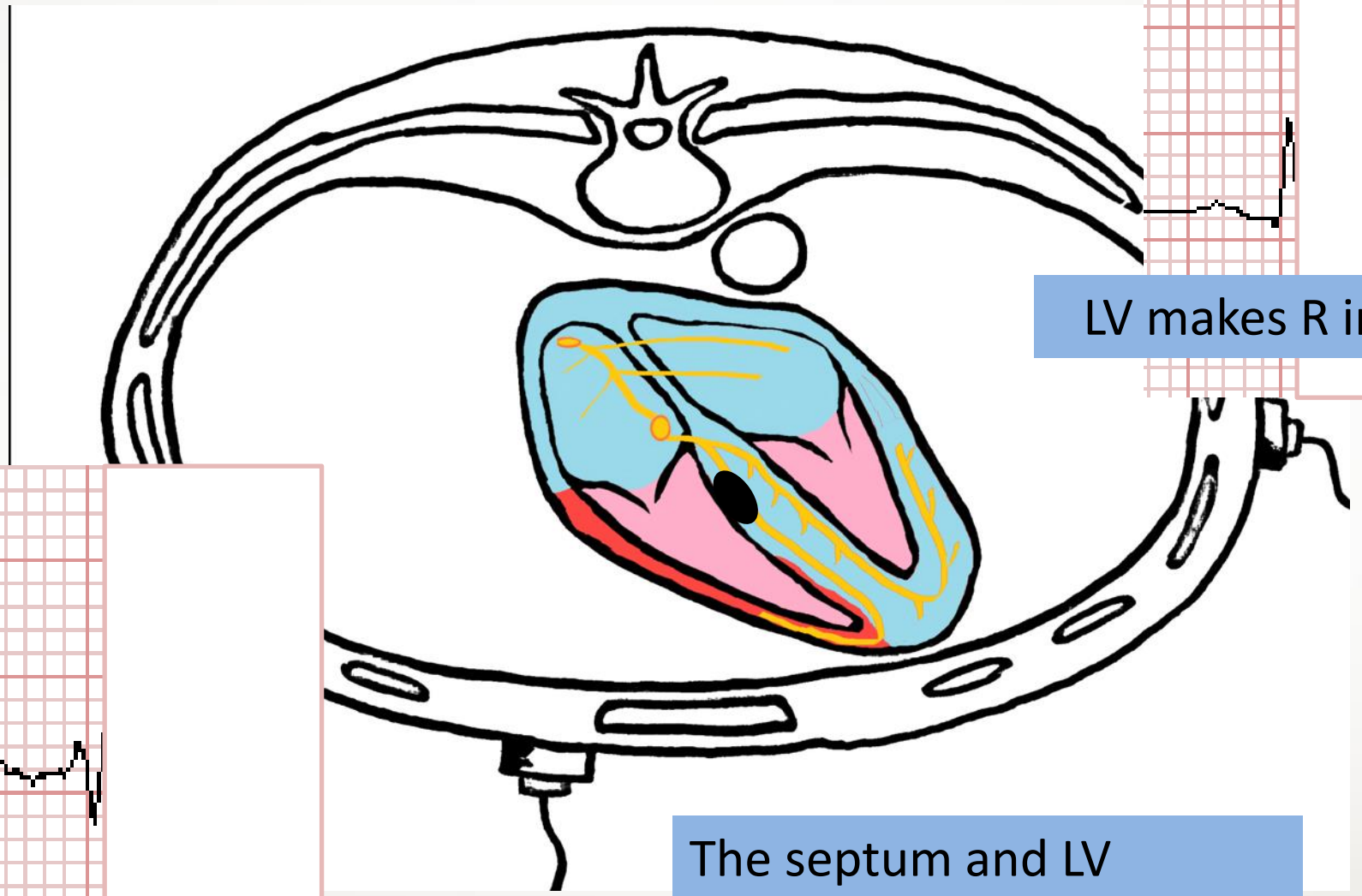


LV makes R in V6

The septum and LV depolarize first

LV makes S in V1

Right Bundle Branch Block

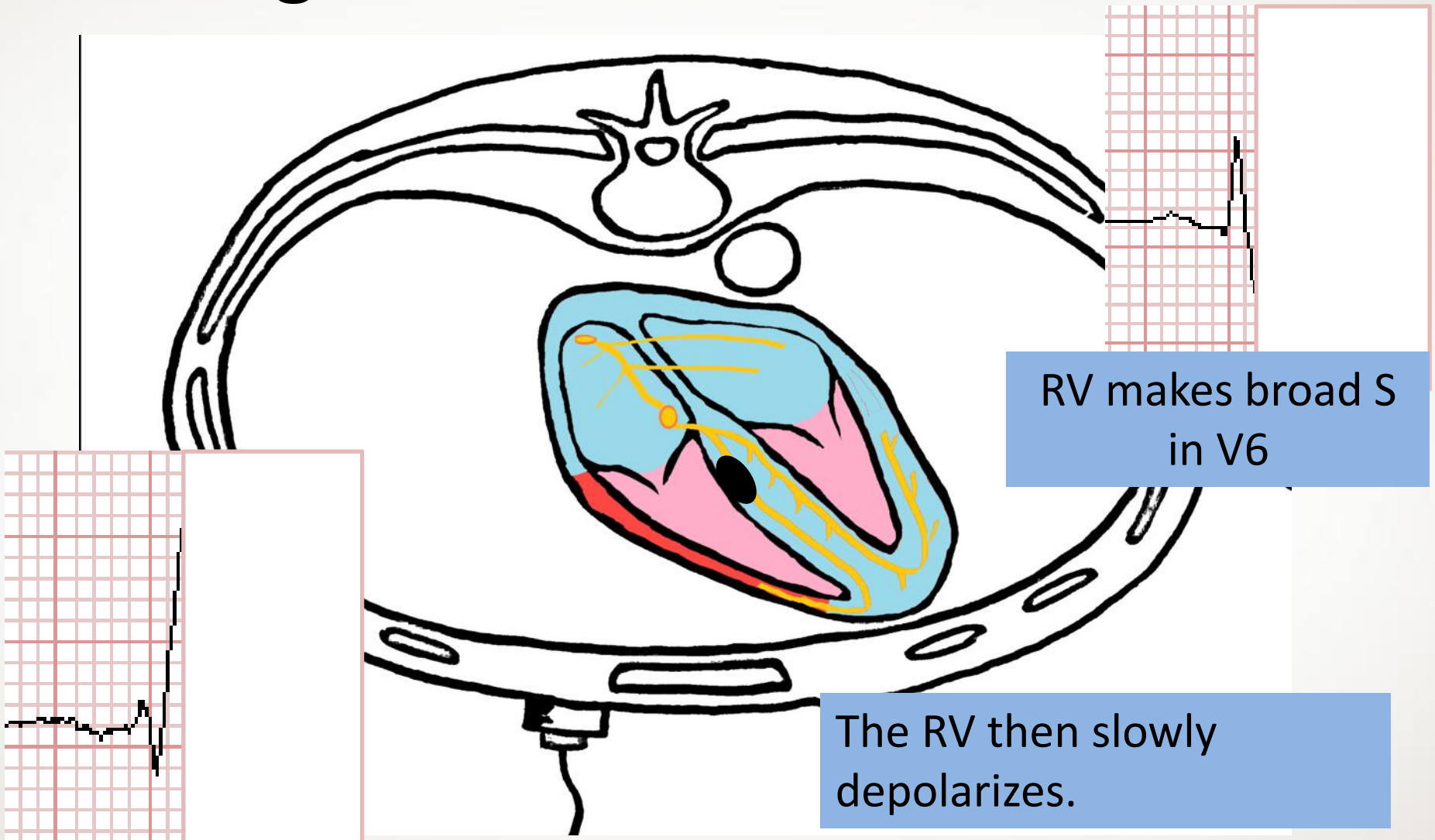


LV makes R in V6

LV makes S in V1

The septum and LV complete depolarization.

Right Bundle Branch Block

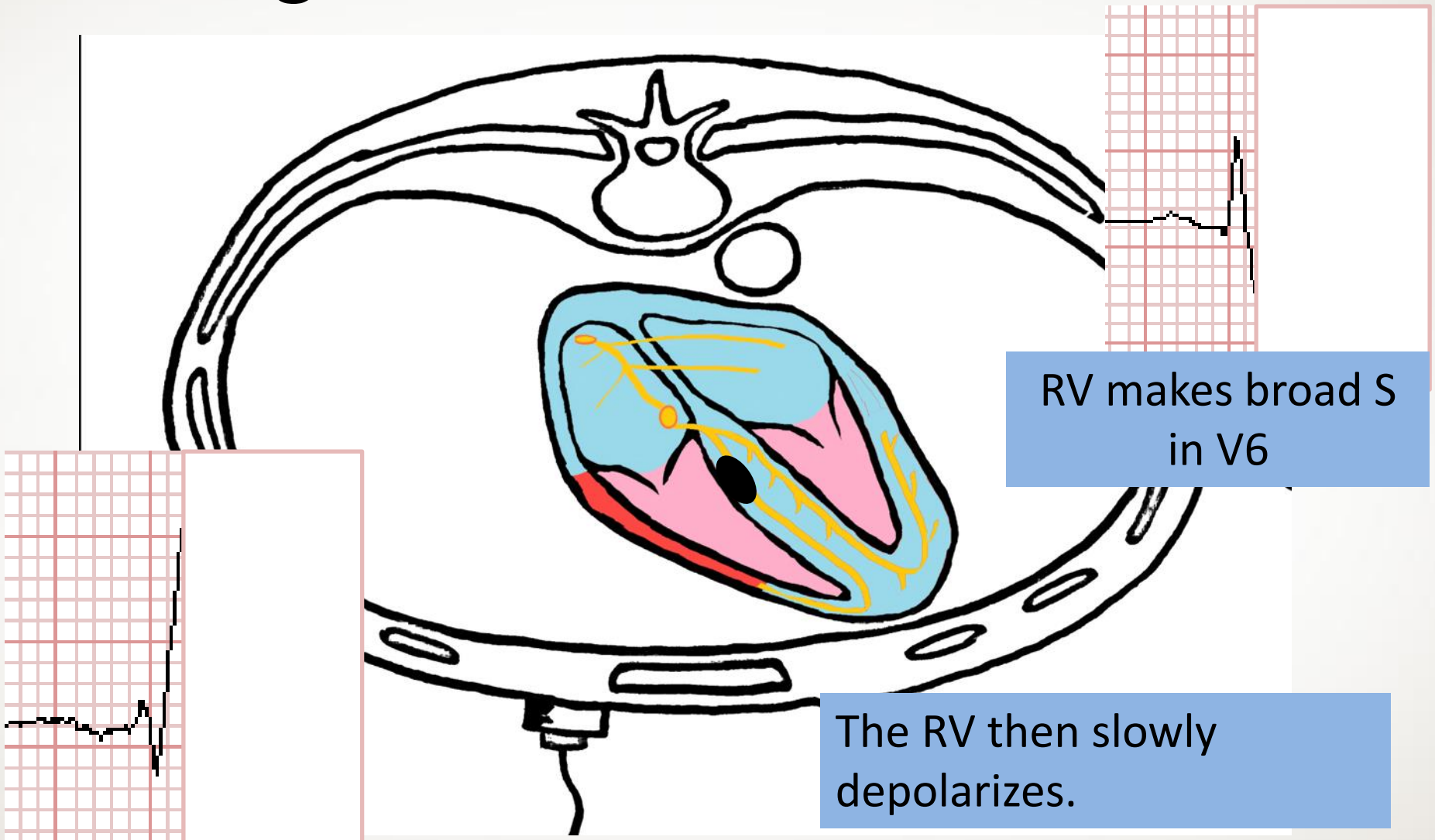


RV makes broad S in V6

The RV then slowly depolarizes.

RV makes R’ in V1

Right Bundle Branch Block

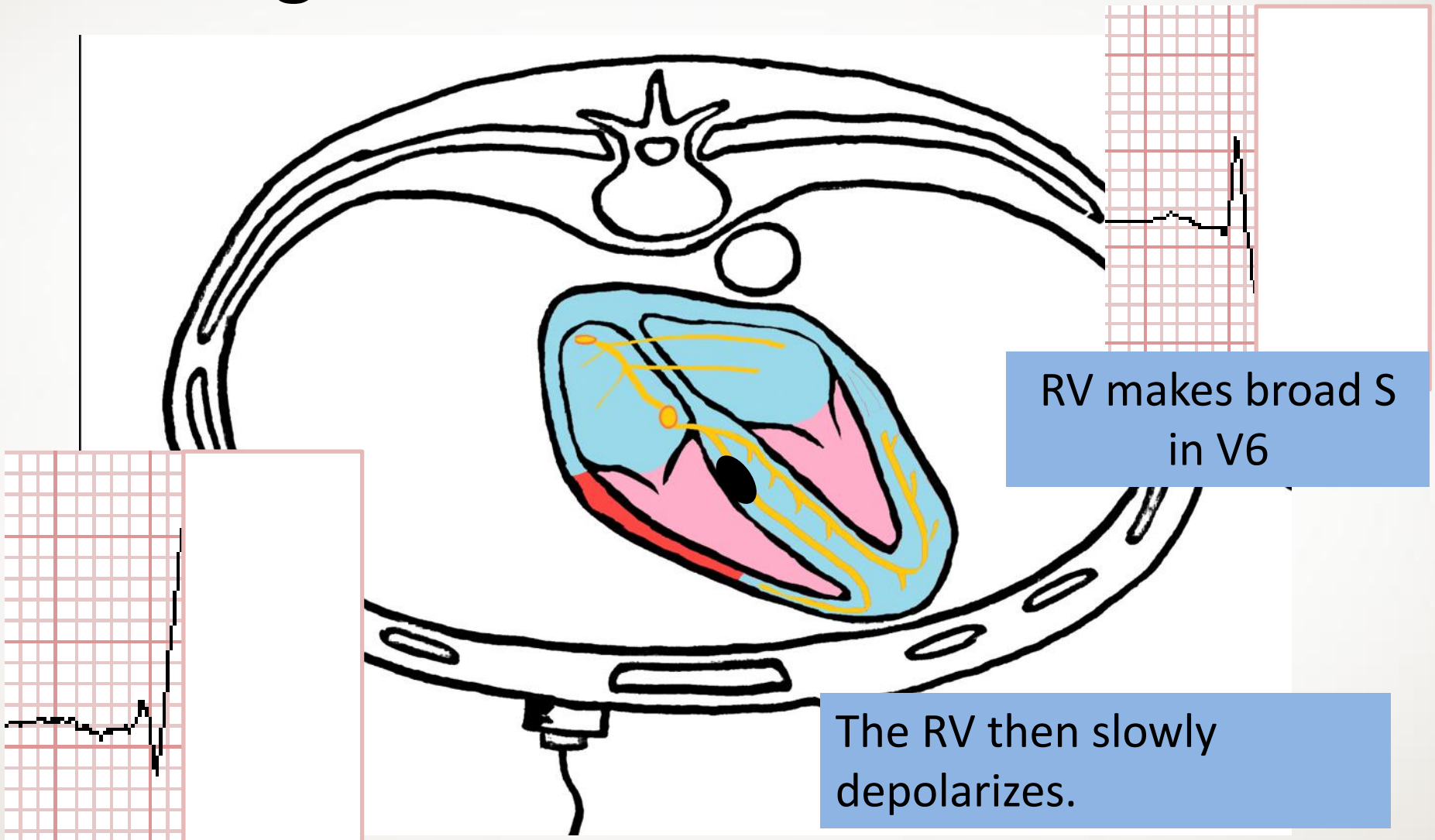


RV makes broad S in V6

The RV then slowly depolarizes.

RV makes R’ in V1

Right Bundle Branch Block



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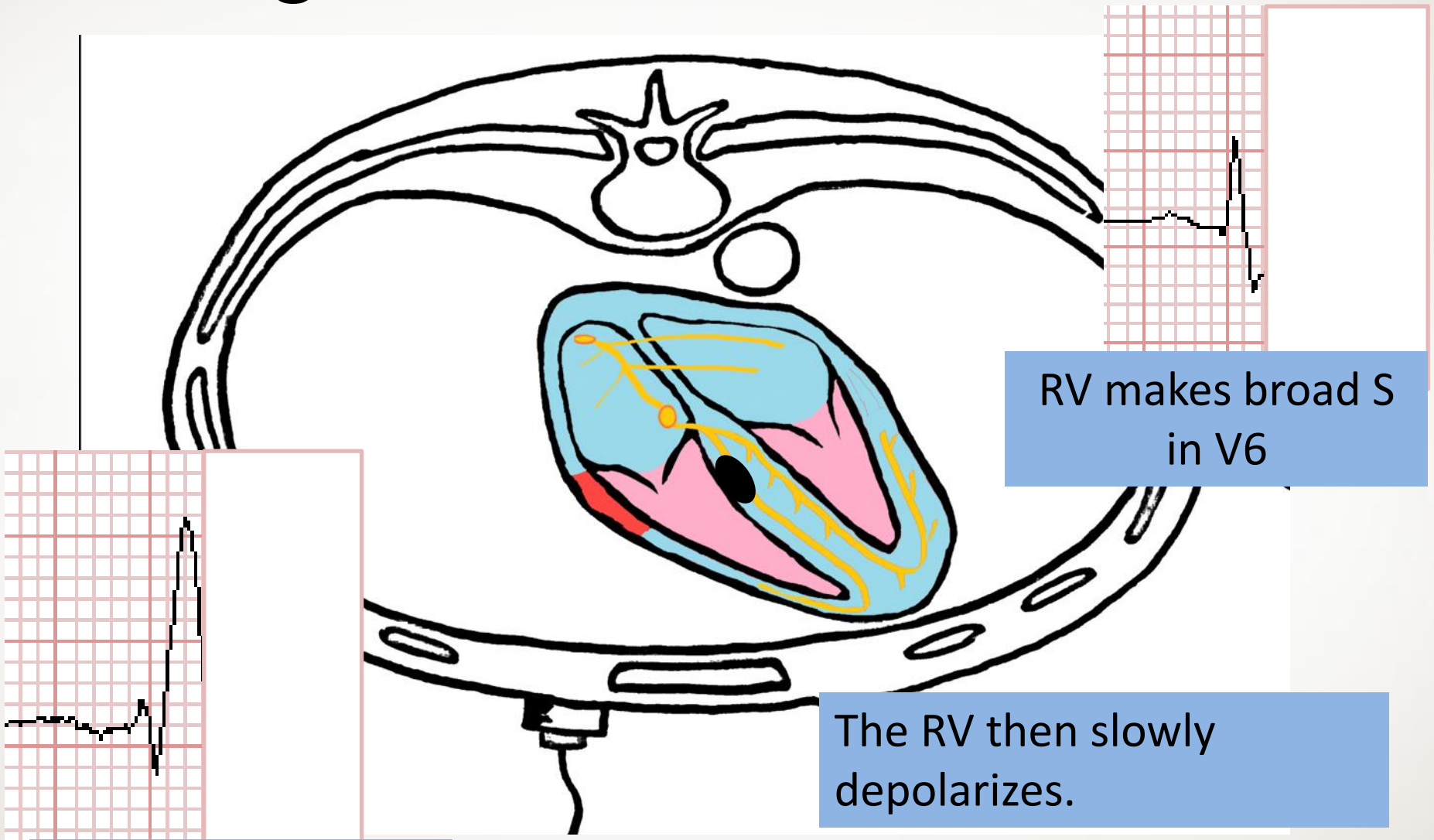
The RV then slowly depolarizes.

RV makes R’ in V1

Right Bundle Branch Block

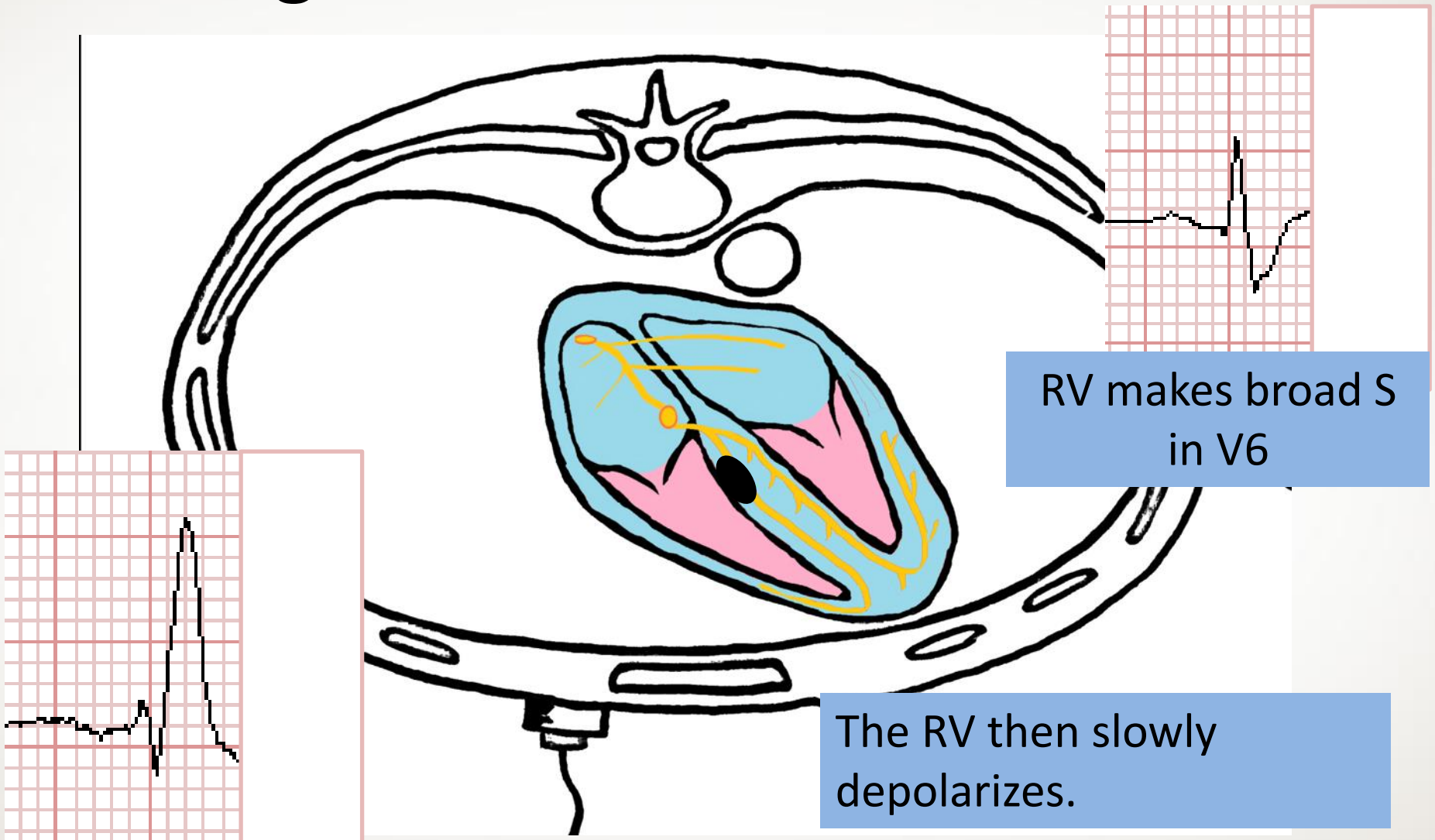


RV makes broad S in V6

The RV then slowly depolarizes.

RV makes R’ in V1

Right Bundle Branch Block



RV makes broad S in V6

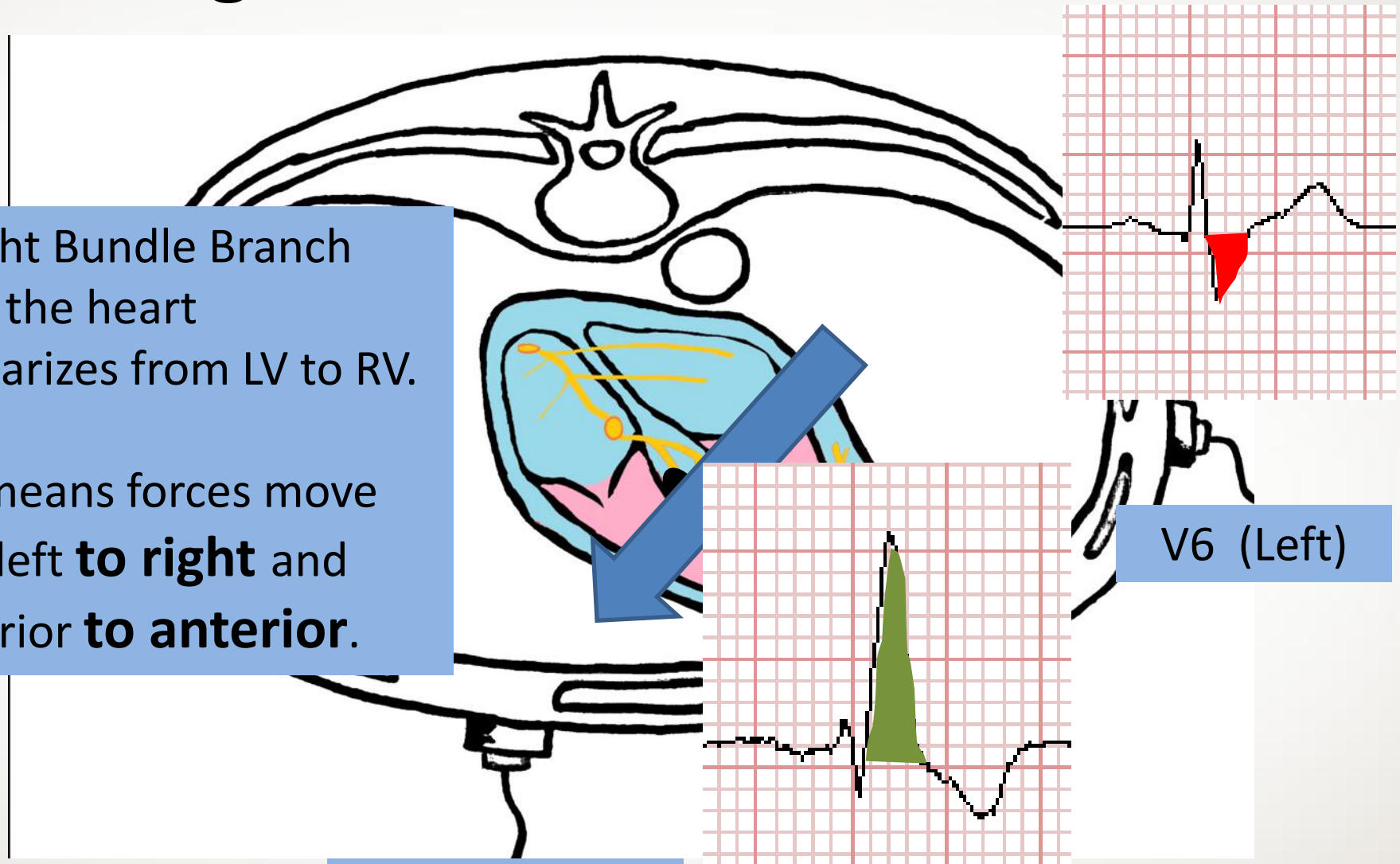
The RV then slowly depolarizes.

RV makes R’ in V1

Right Bundle Branch Block

In Right Bundle Branch Block the heart depolarizes from LV to RV.

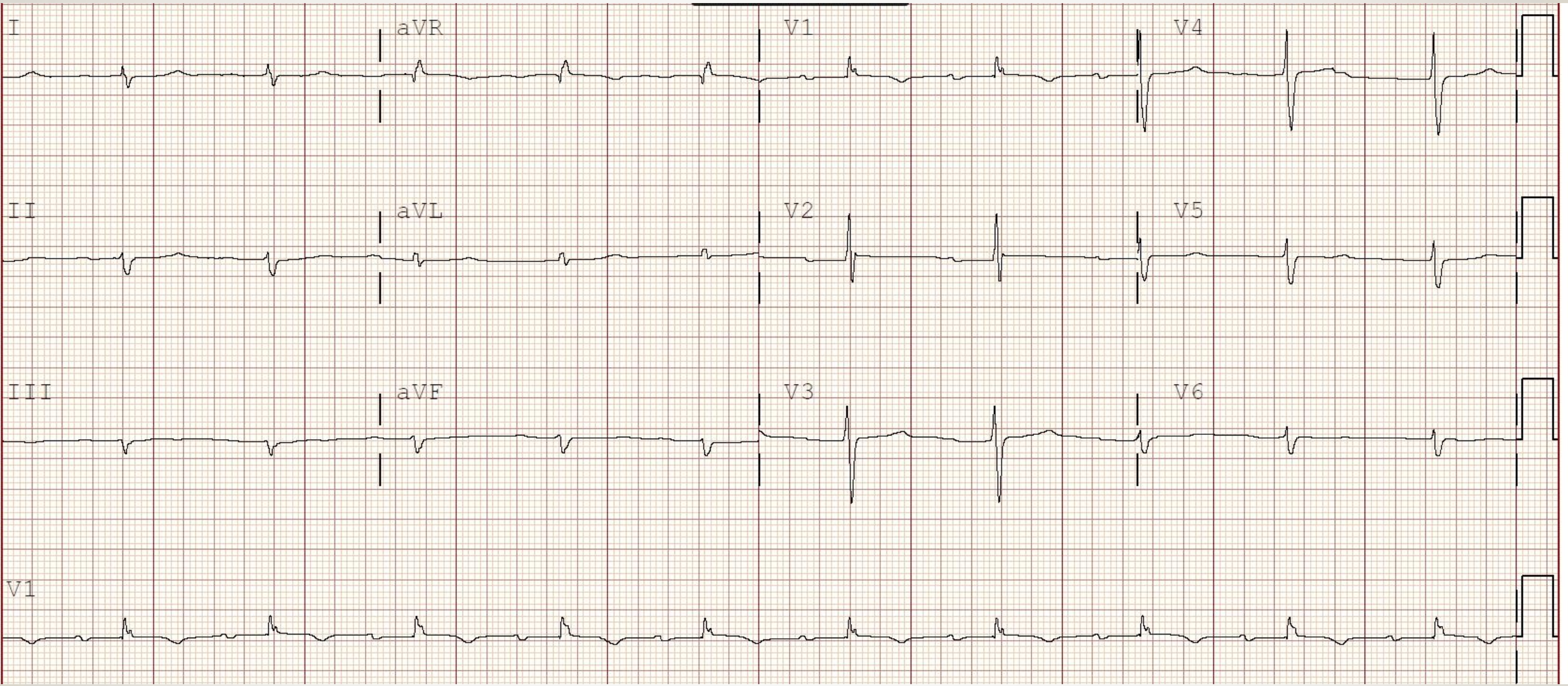
This means forces move from left **to right** and posterior **to anterior**.



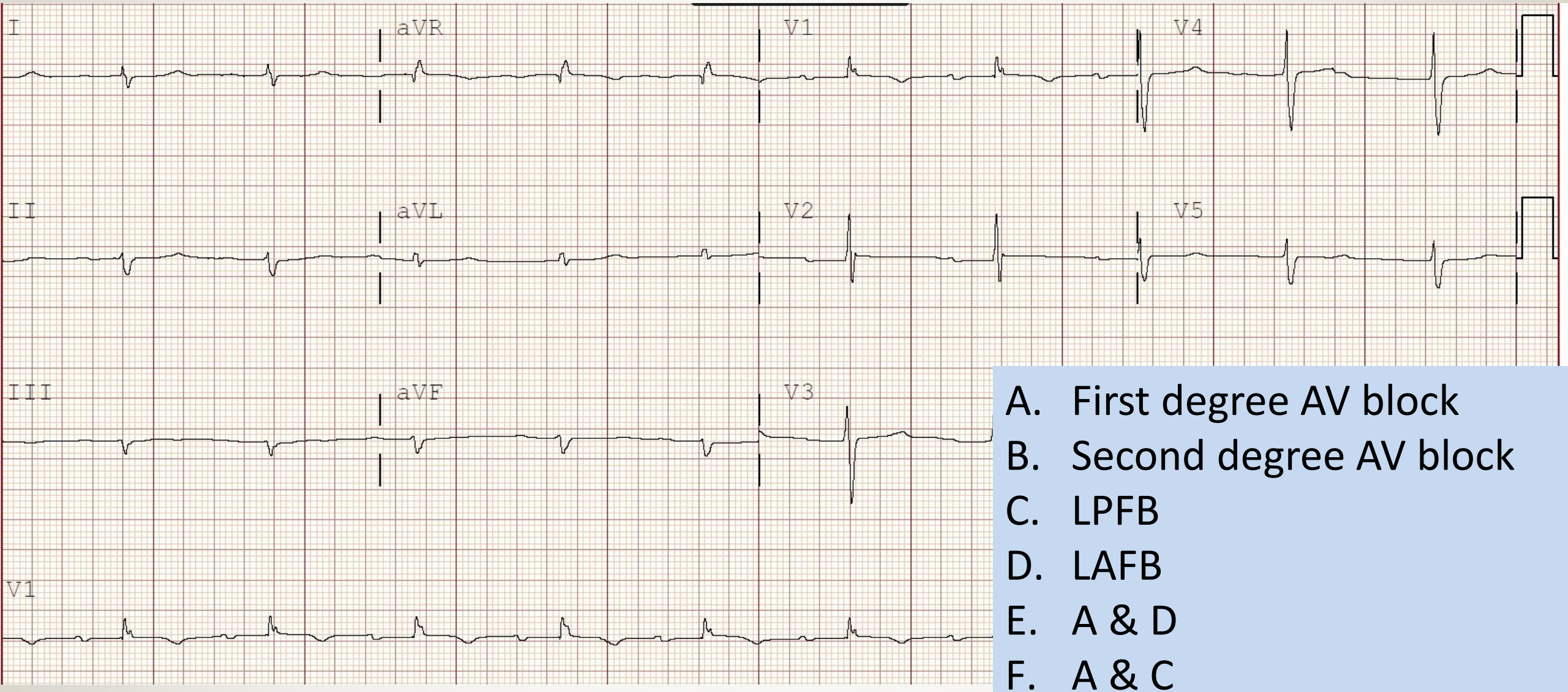
V6 (Left)

V1 (Anterior)

This is another example of RBBB, they don't all look like bunny ears

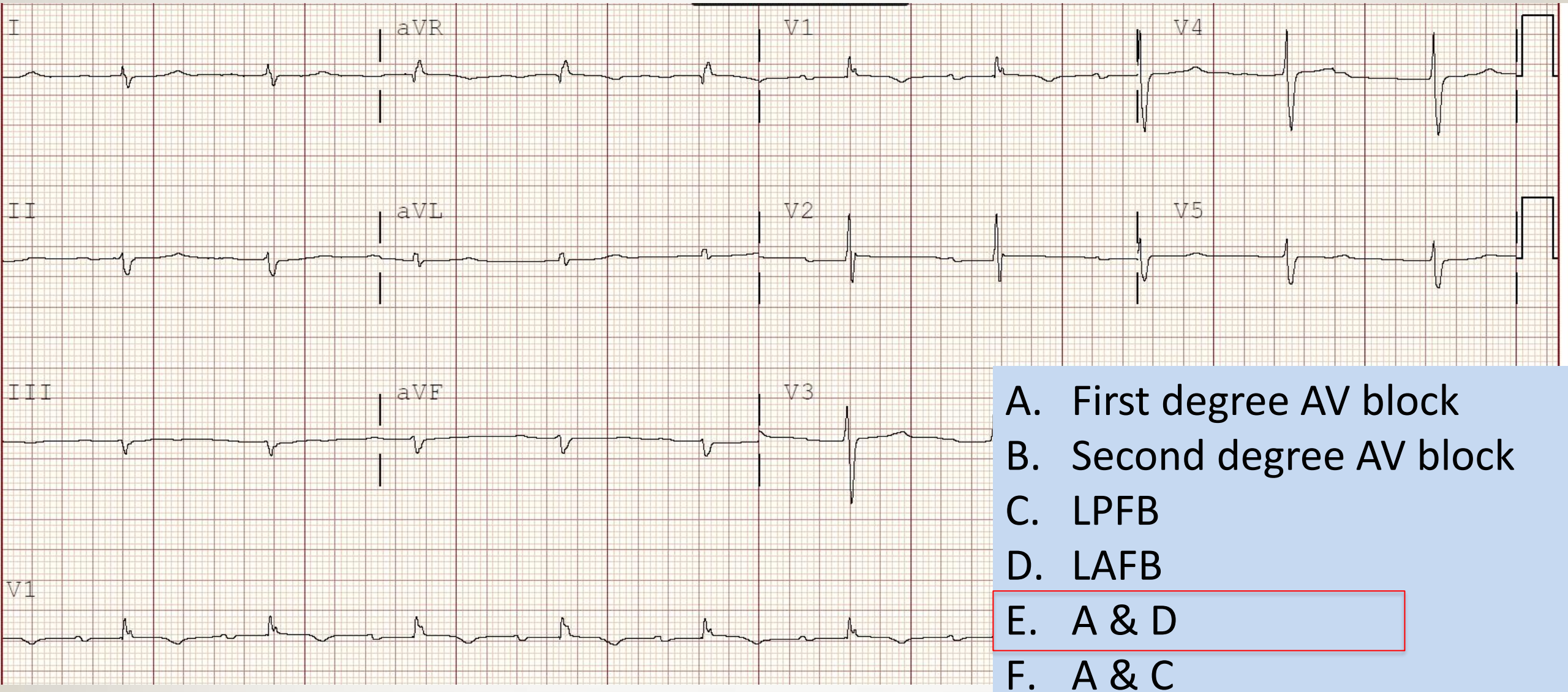


What else is abnormal here?



A. First degree AV block
B. Second degree AV block
C. LPFB
D. LAFB
E. A & D
F. A & C

What else is abnormal here?



A. First degree AV block
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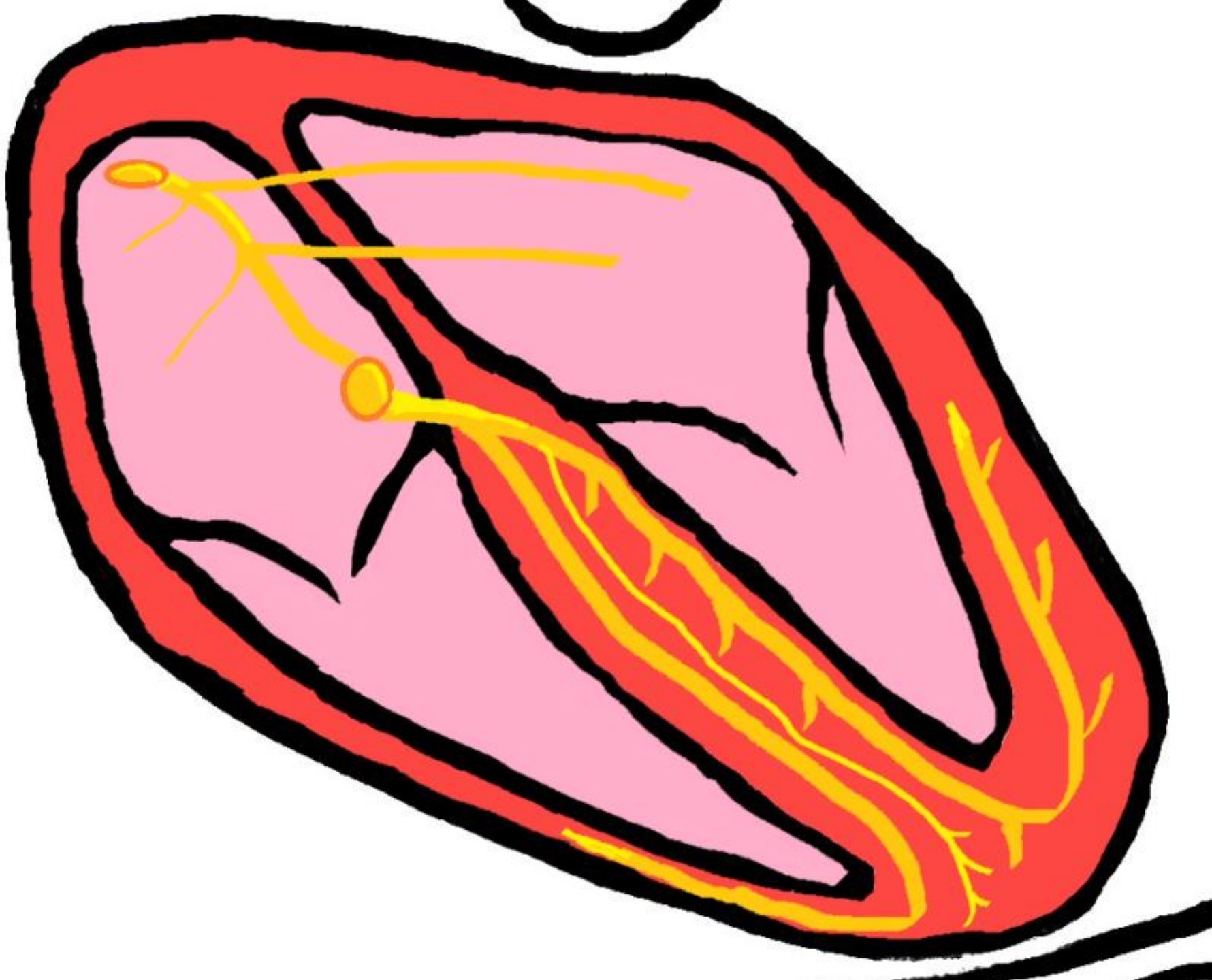
AV Conduction

Physiology of AV Conduction



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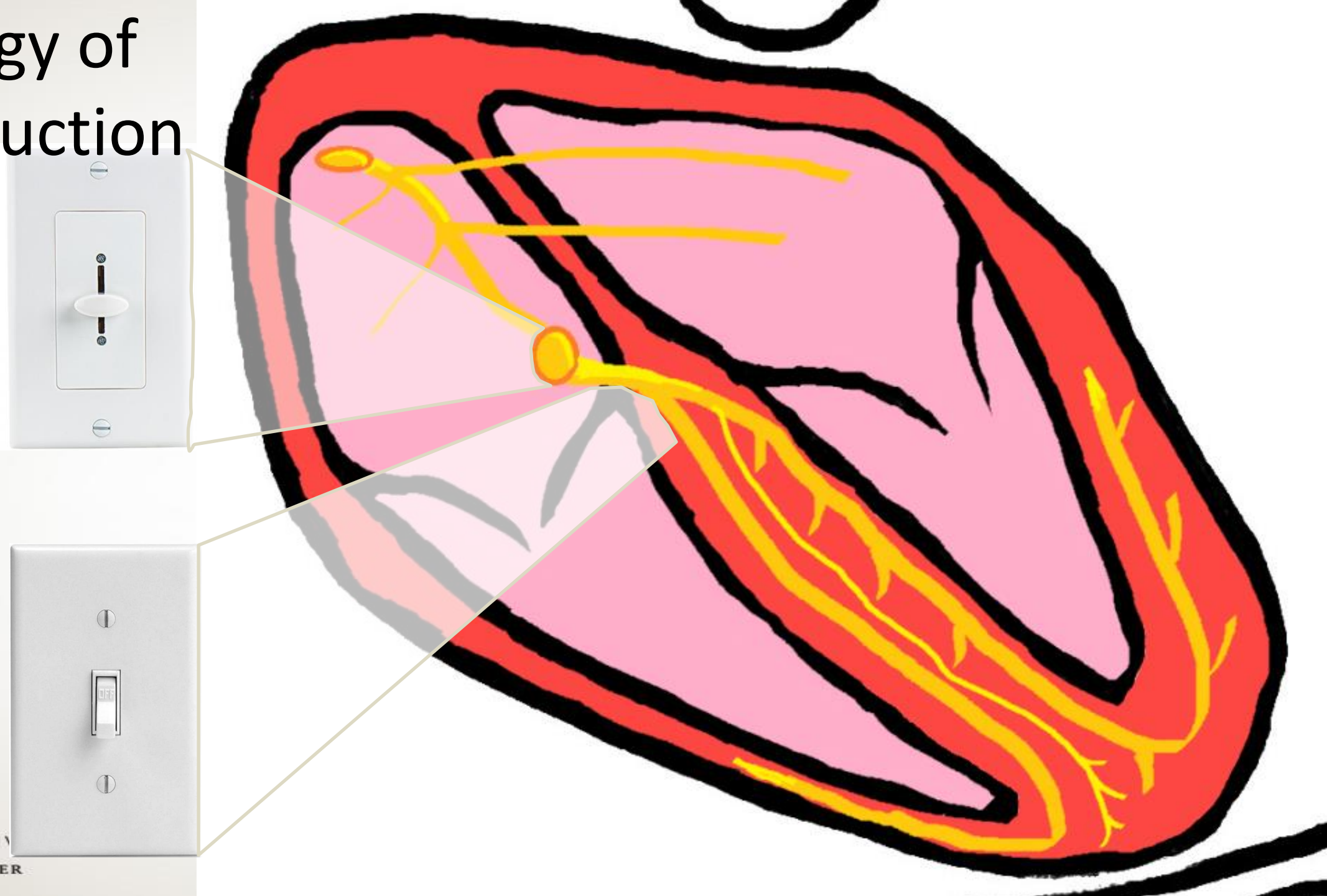
Physiology of AV Conduction



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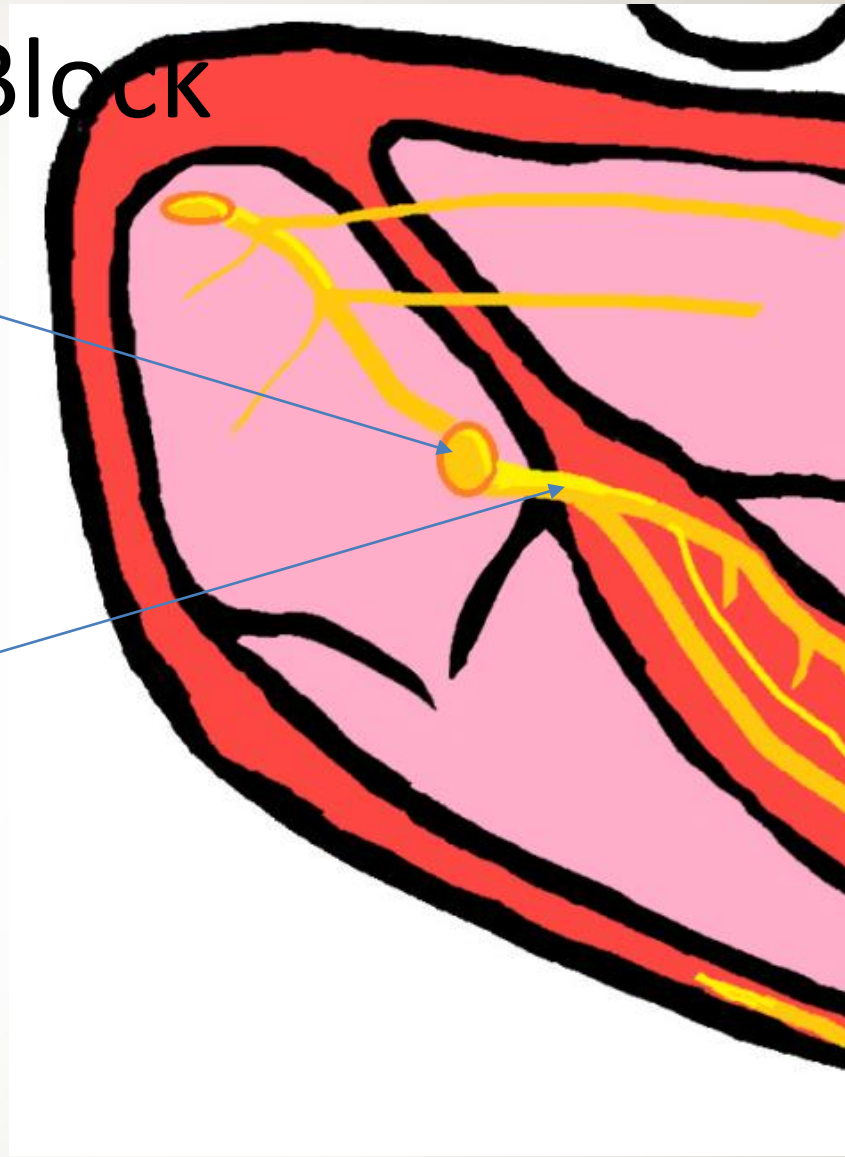
Second Degree Heart Block

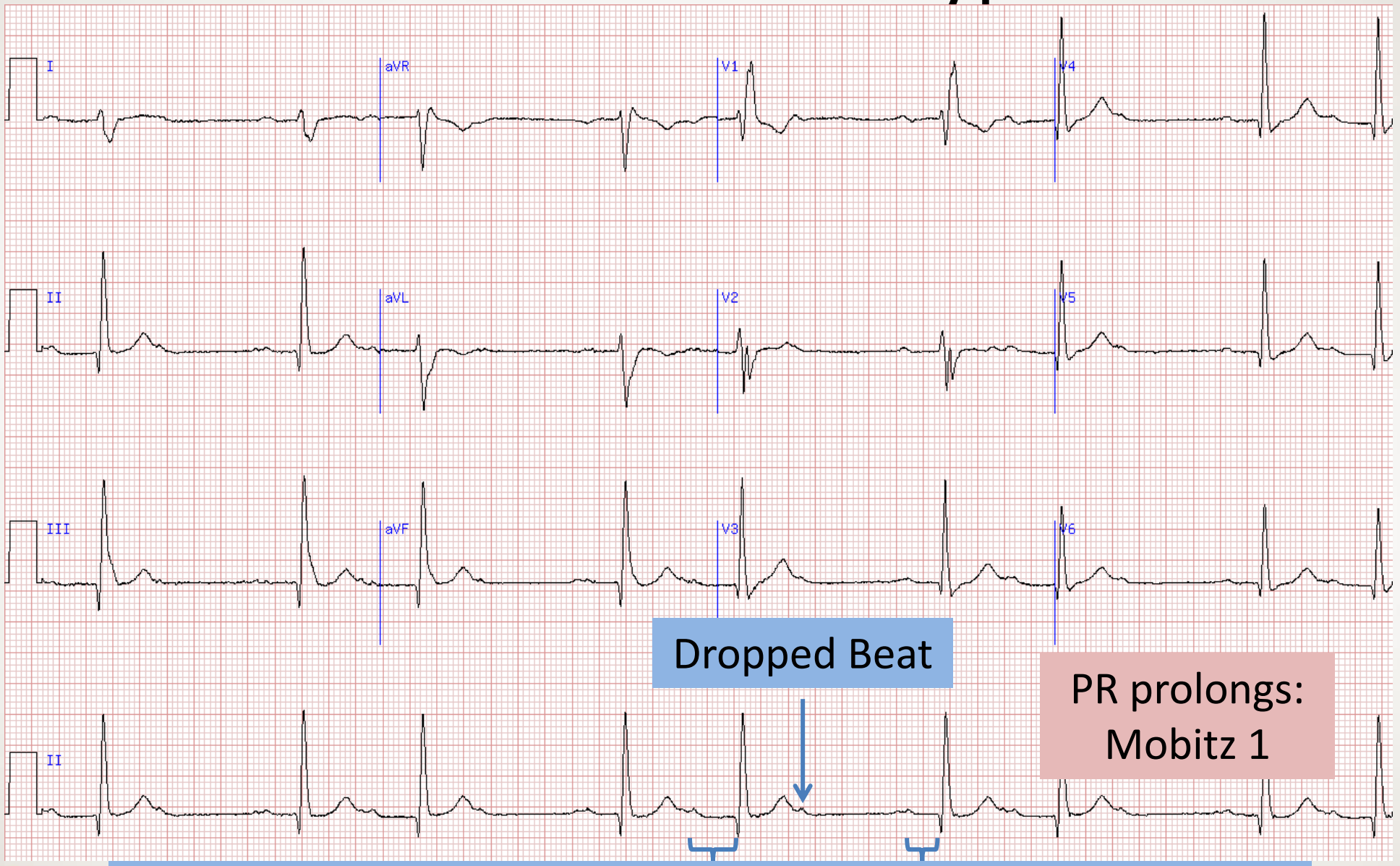
1. Mobitz I (Wenckebach)- Characterized by progressive PR interval prolongation prior to a dropped beat.

2. Mobitz II- Constant PR interval with intermittent dropped beats.



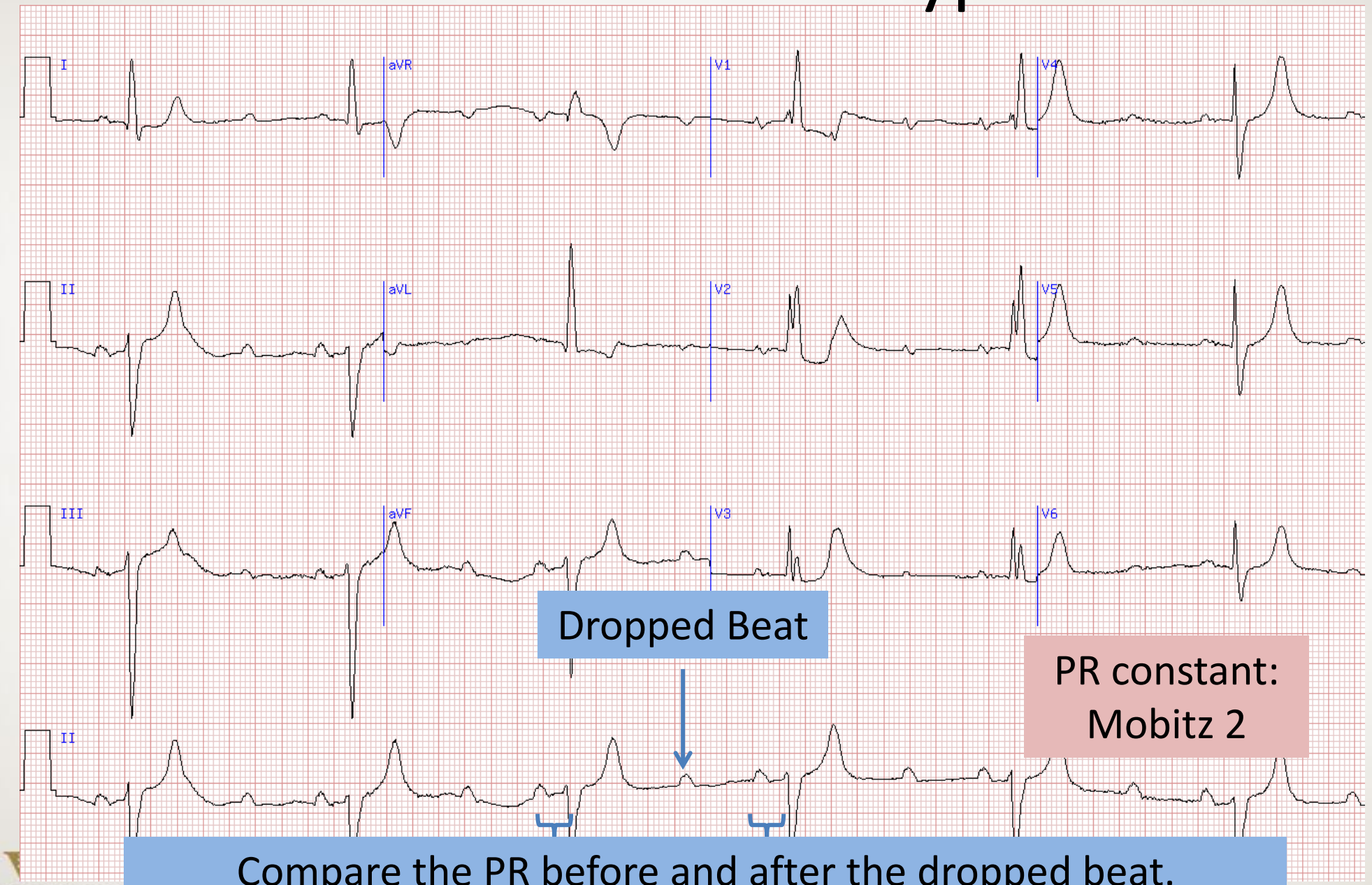
* Note: When beats are conducted in a 2:1 pattern Mobitz I and Mobitz II cannot be differentiated.

AV Block- Mobitz Type I



Compare the PR before and after the dropped beat.

AV Block- Mobitz Type II



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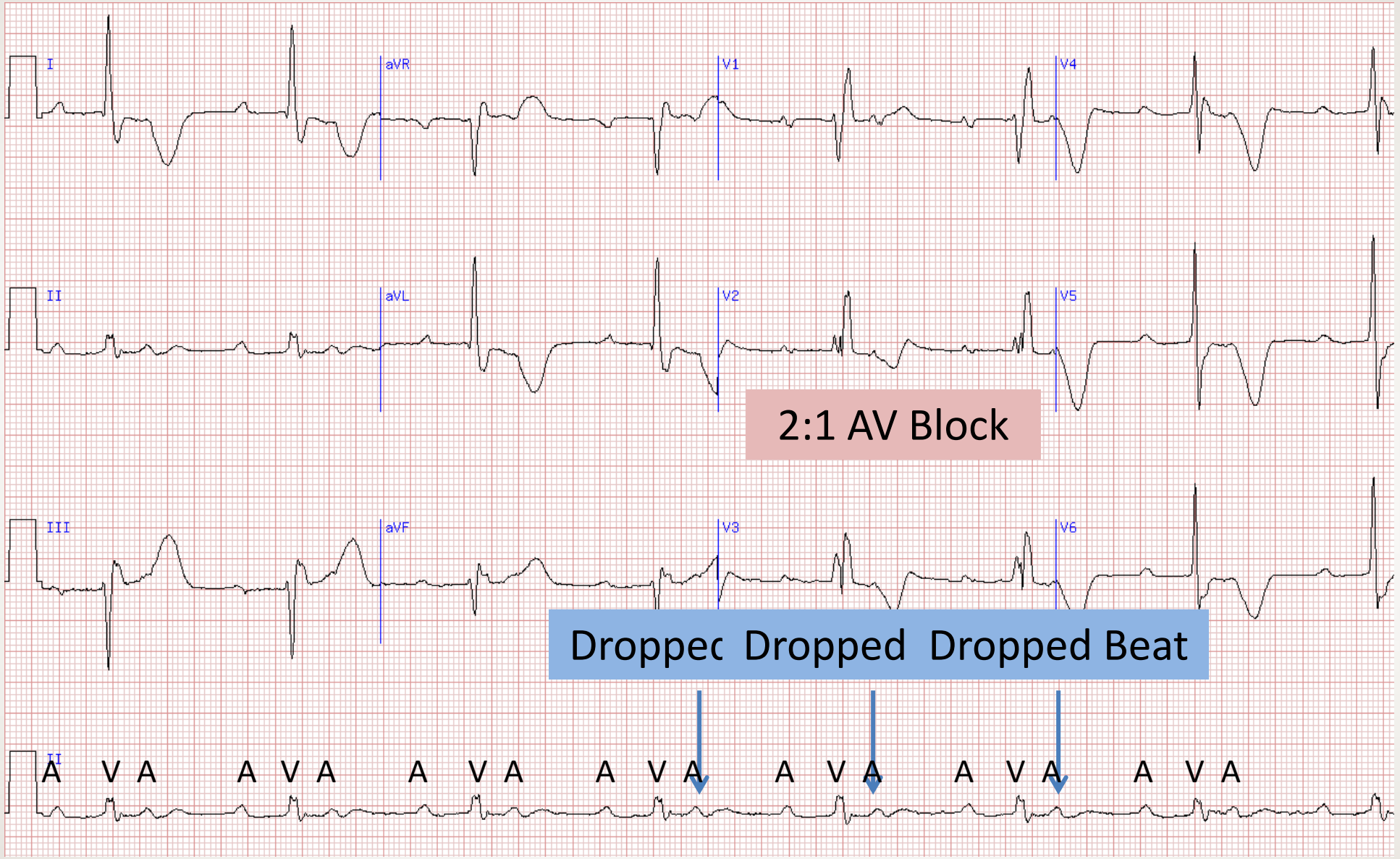
AV Block- 2:1



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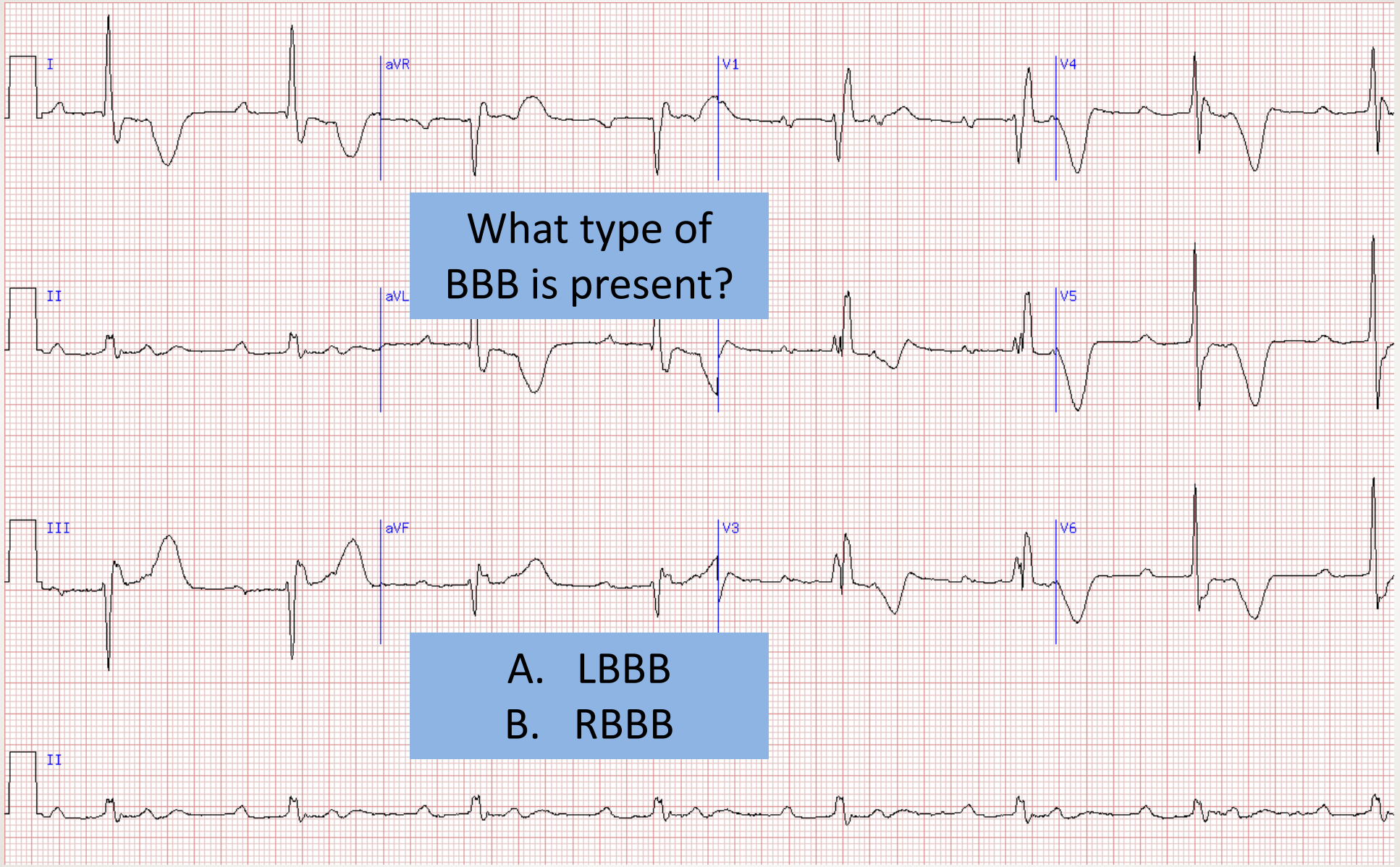
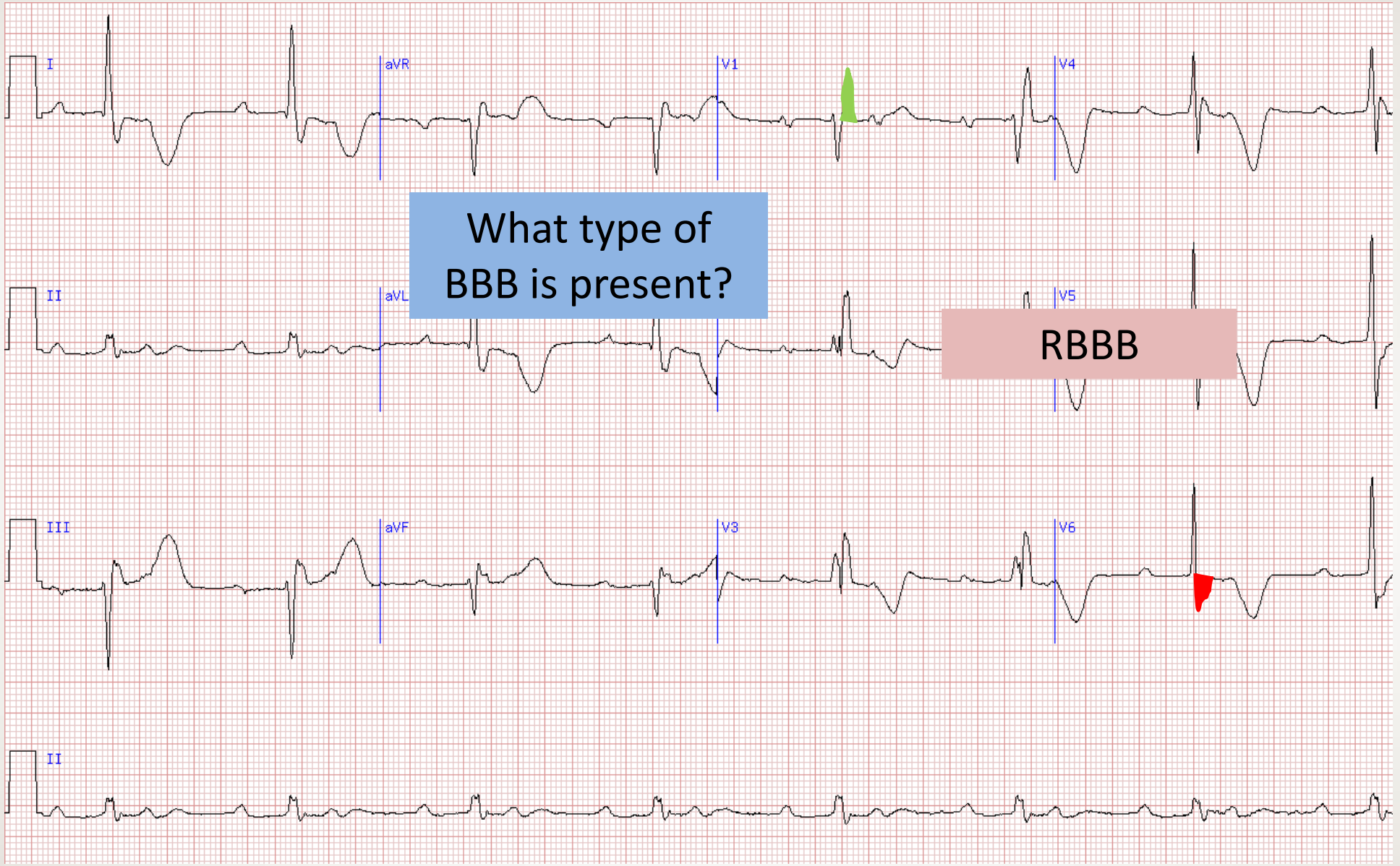
AV Block



What type of BBB is present?

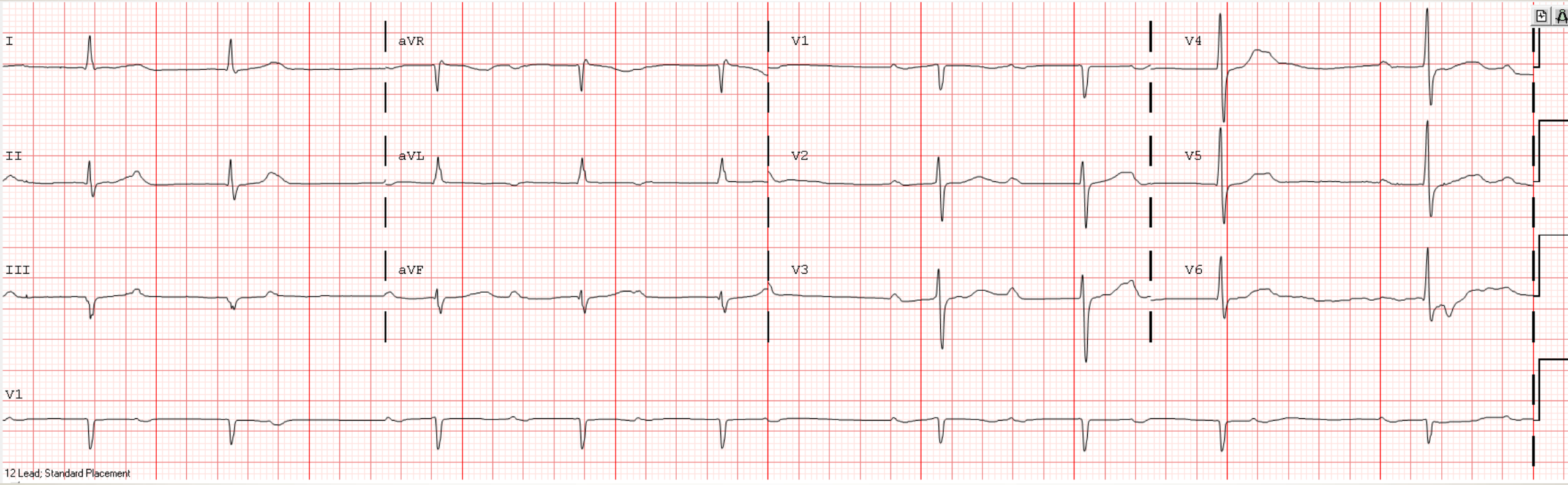
A. LBBB
B. RBBB

AV Block



What type of BBB is present?

RBBB



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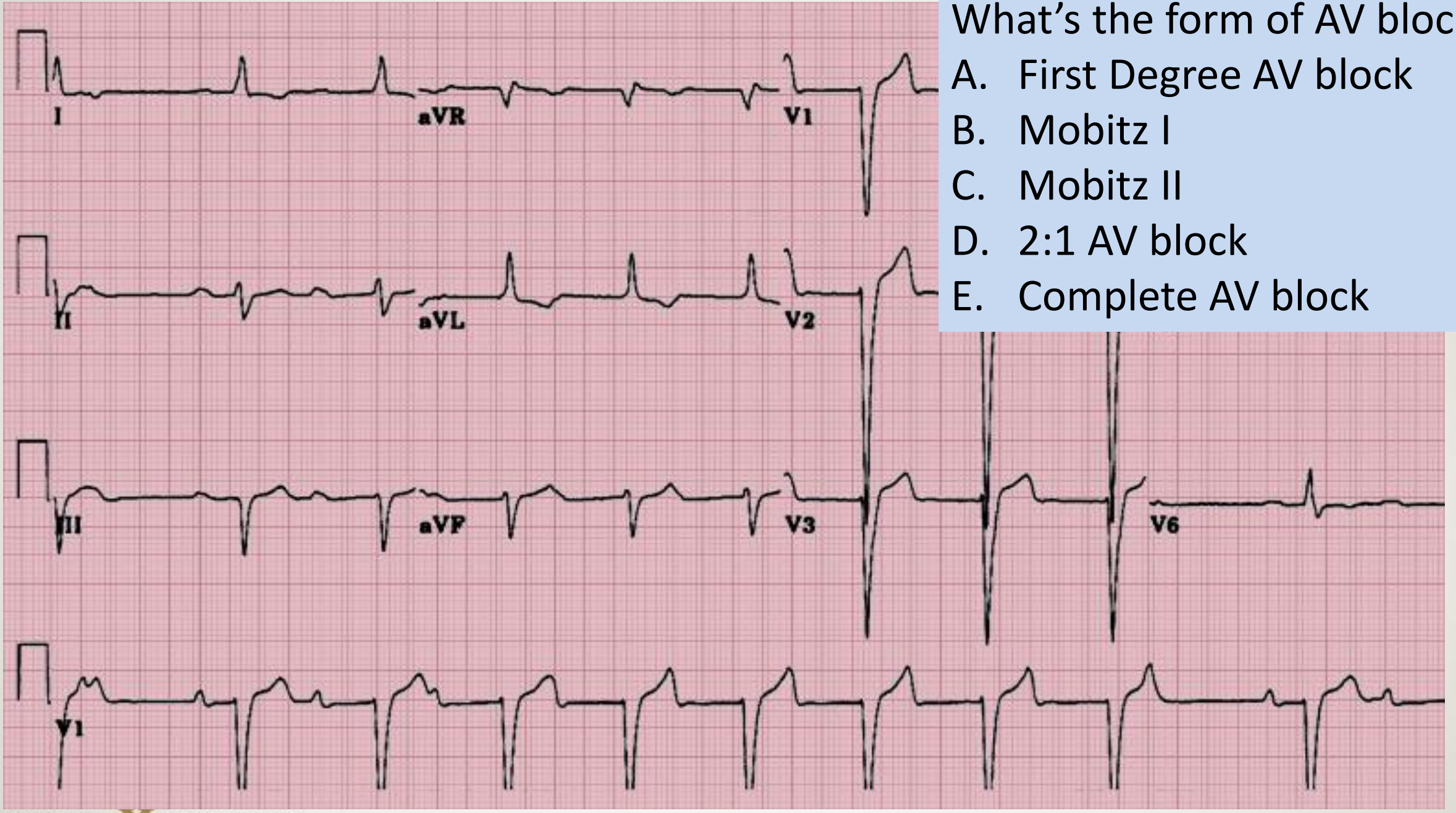
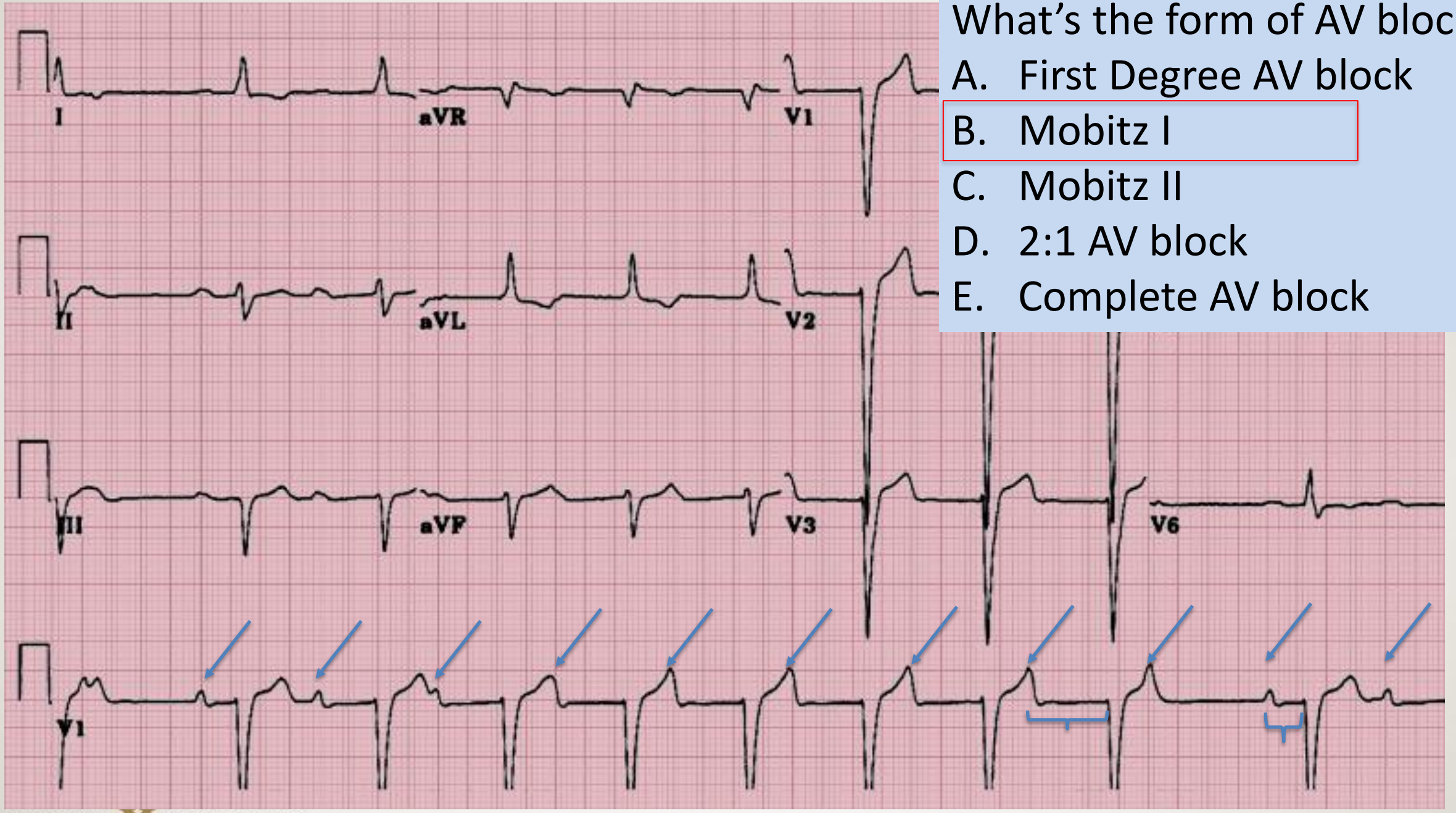
006718357



What's the form of AV block?

A. First Degree AV block
B. Mobitz I
C. Mobitz II
D. 2:1 AV block
E. Complete AV block



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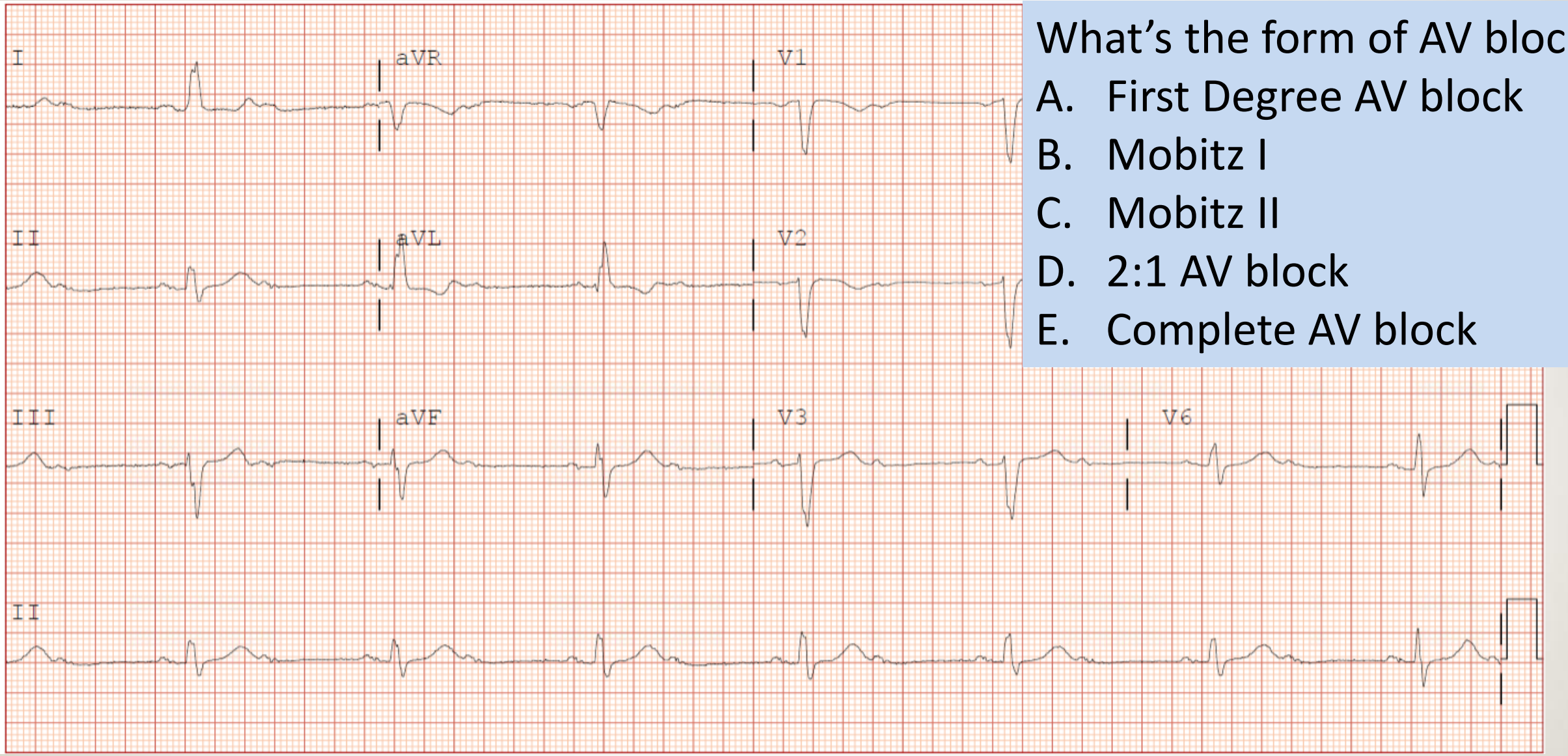
83yo F with lightheadedness



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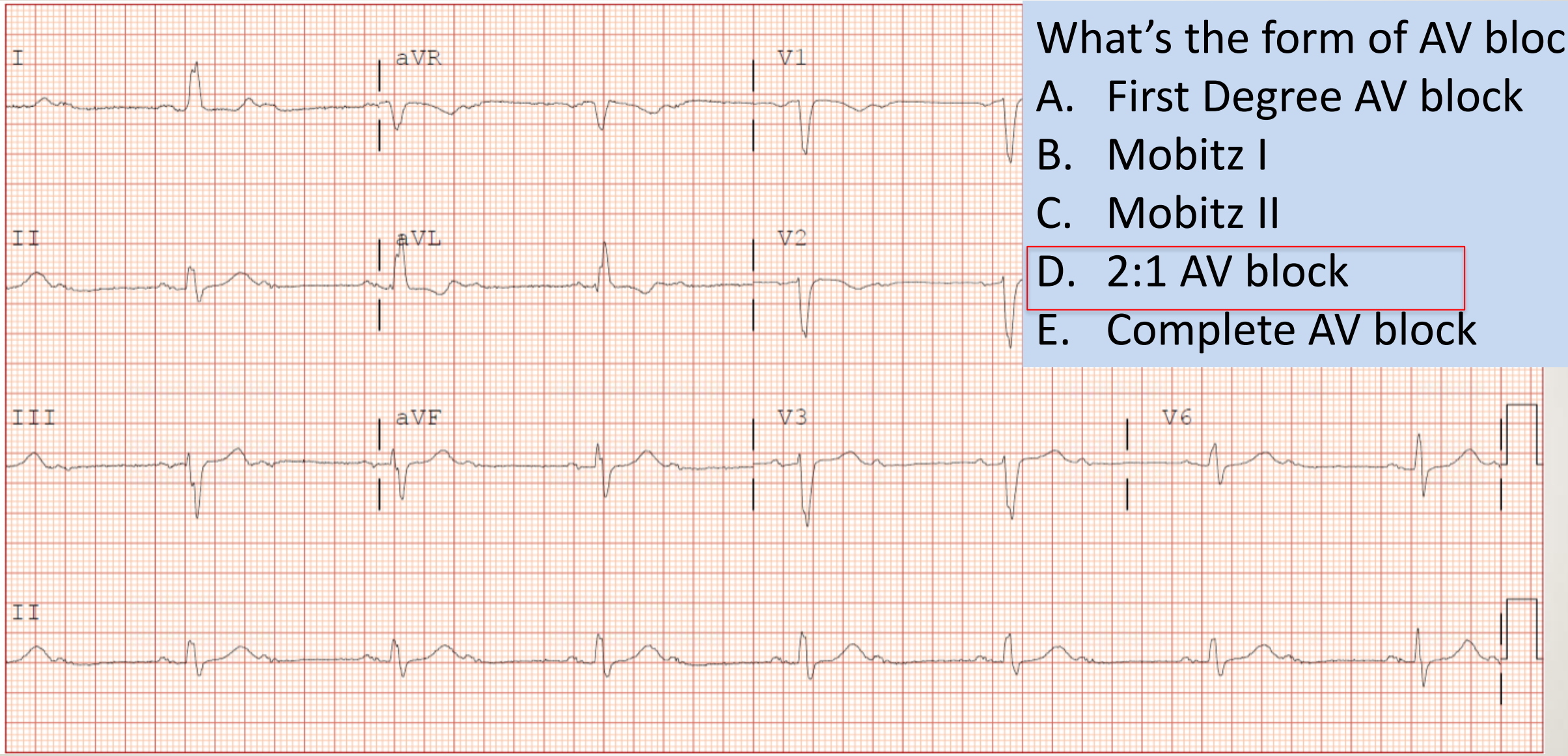

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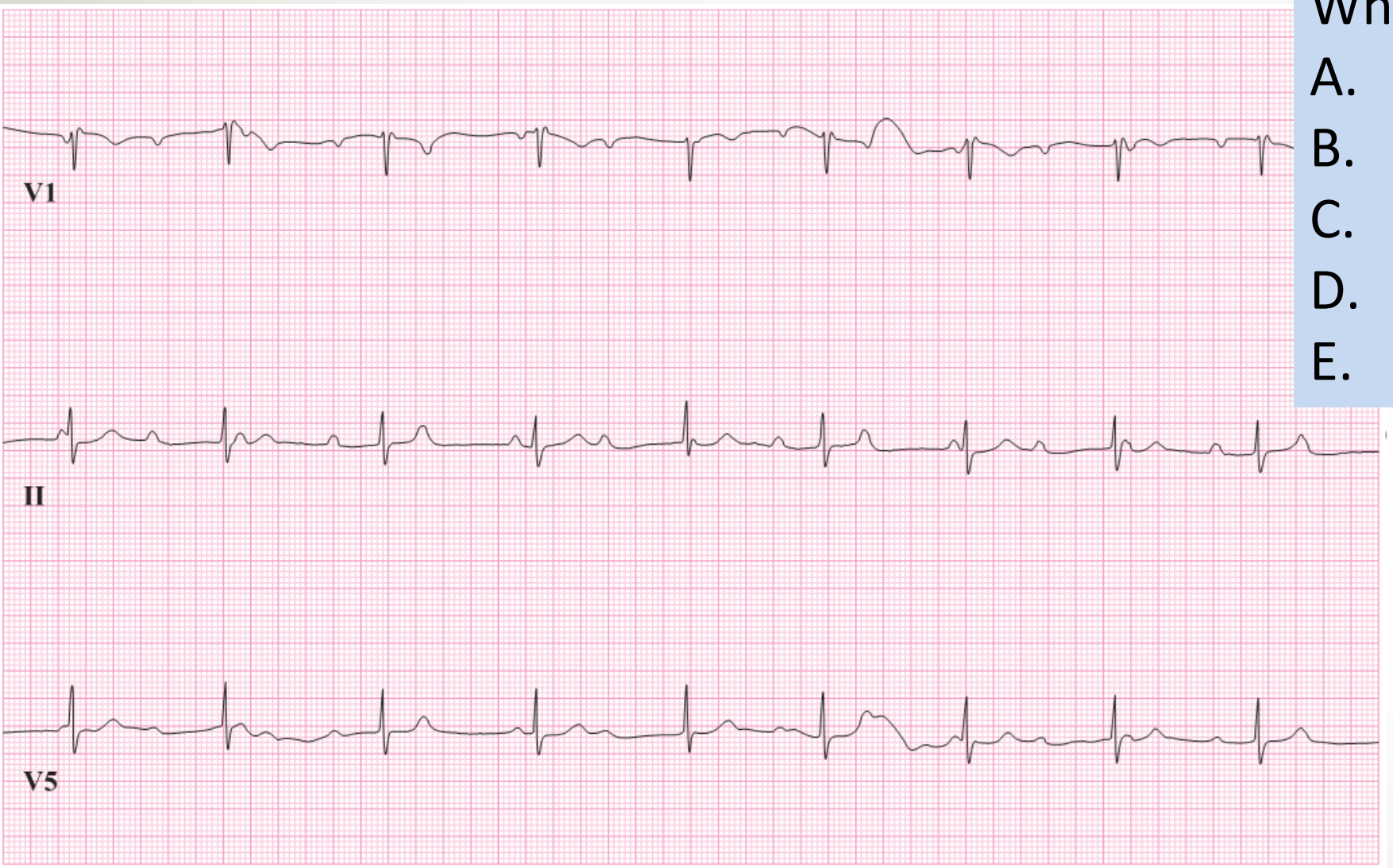

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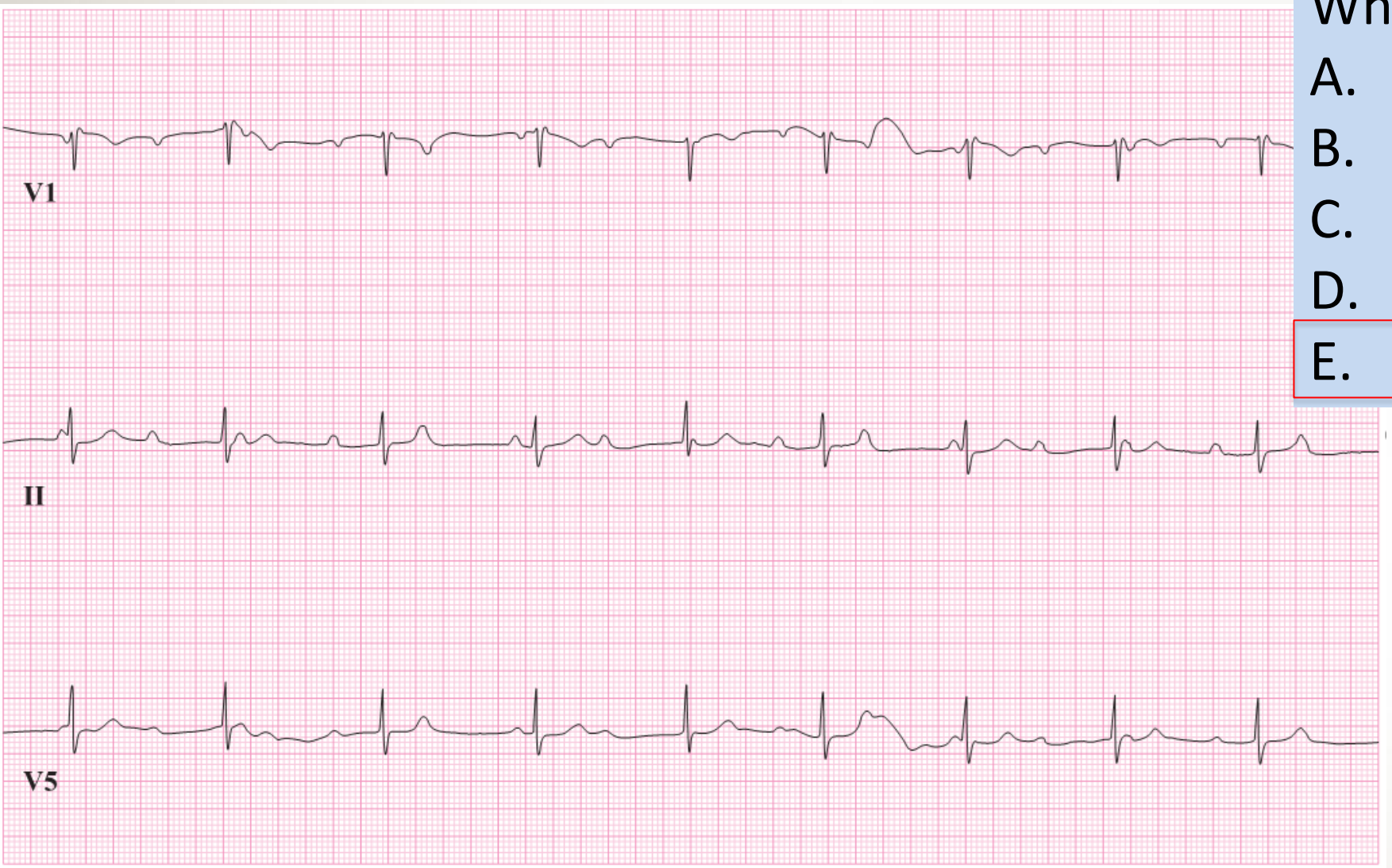

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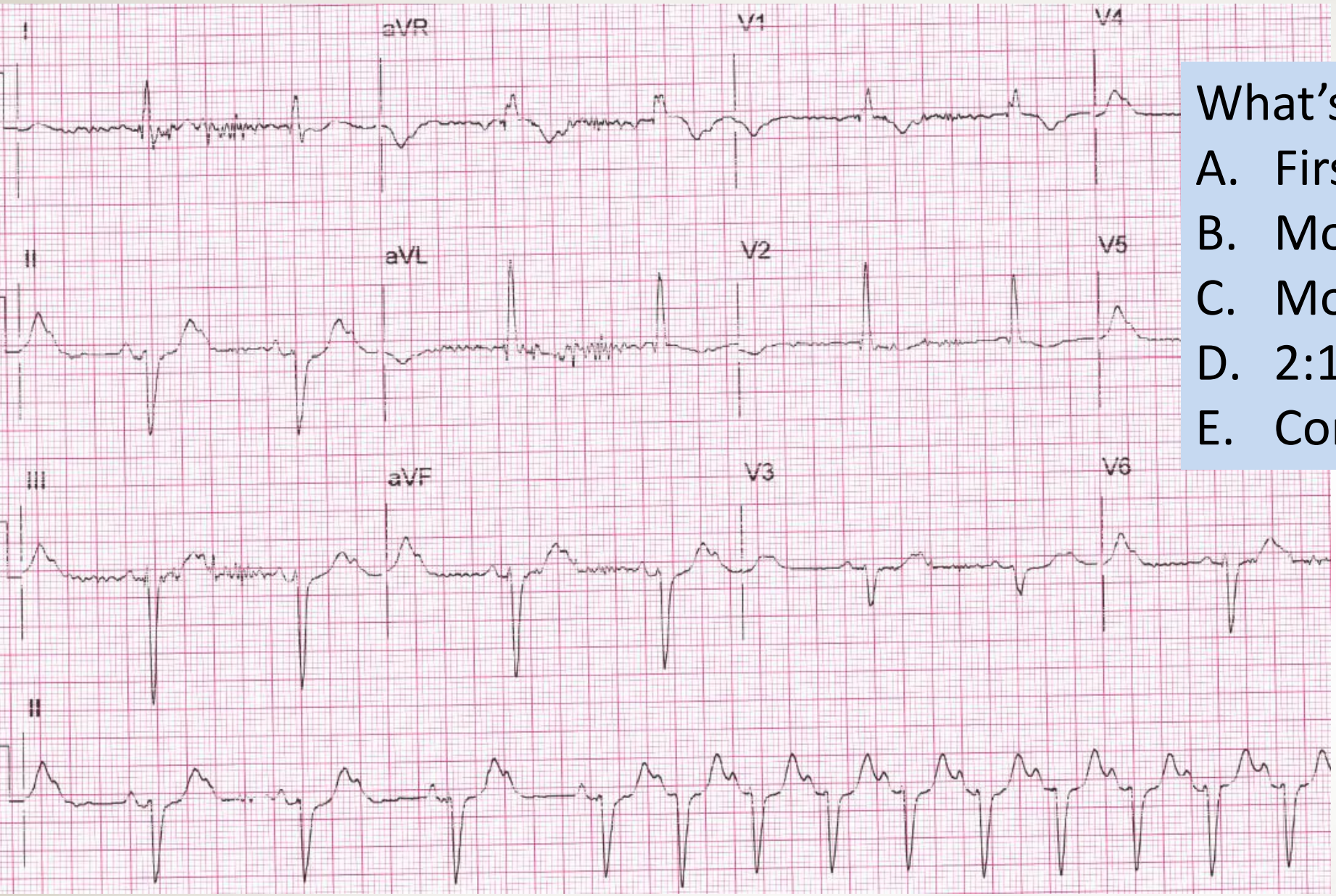

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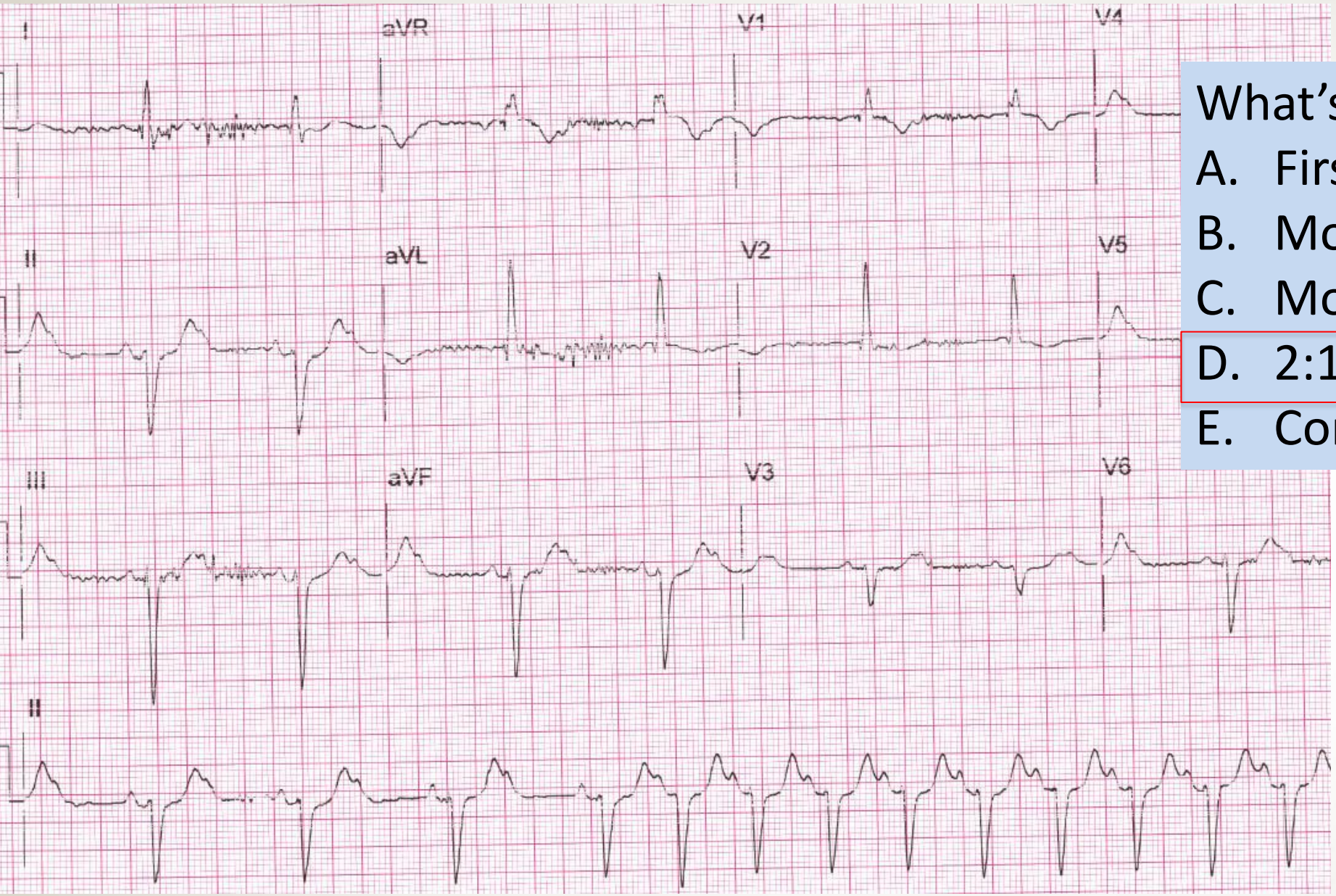

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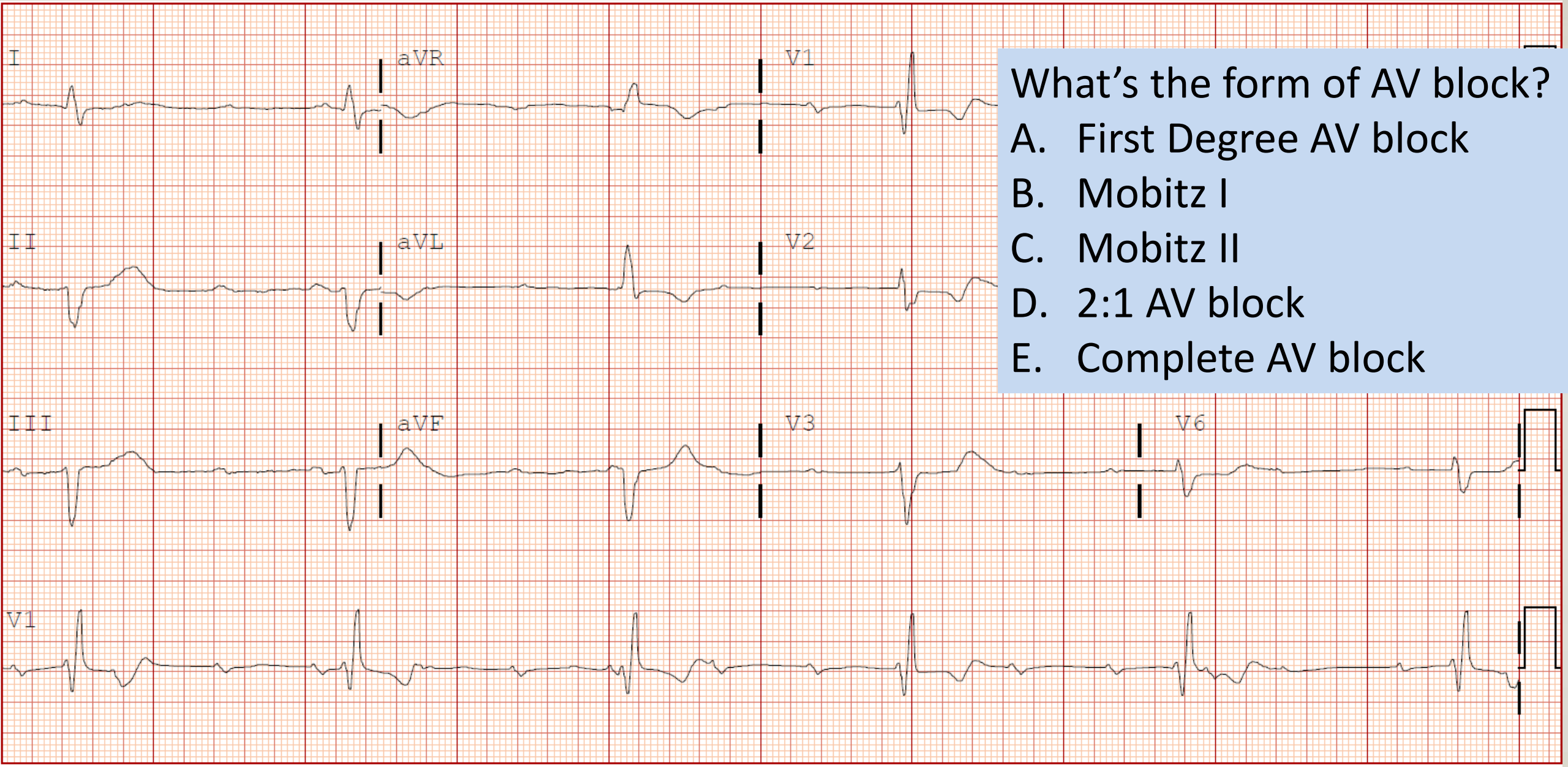

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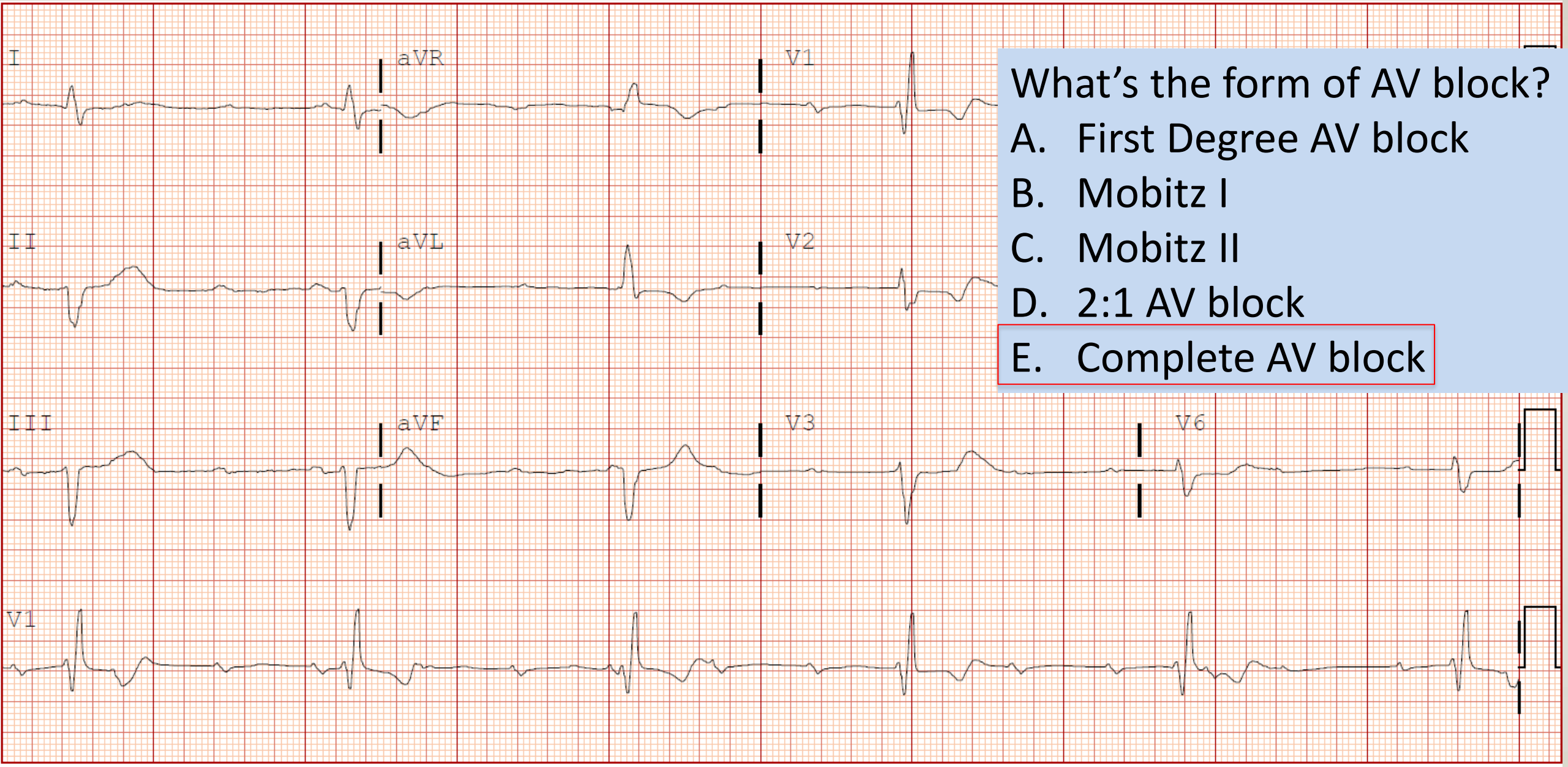

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E. Complete AV block

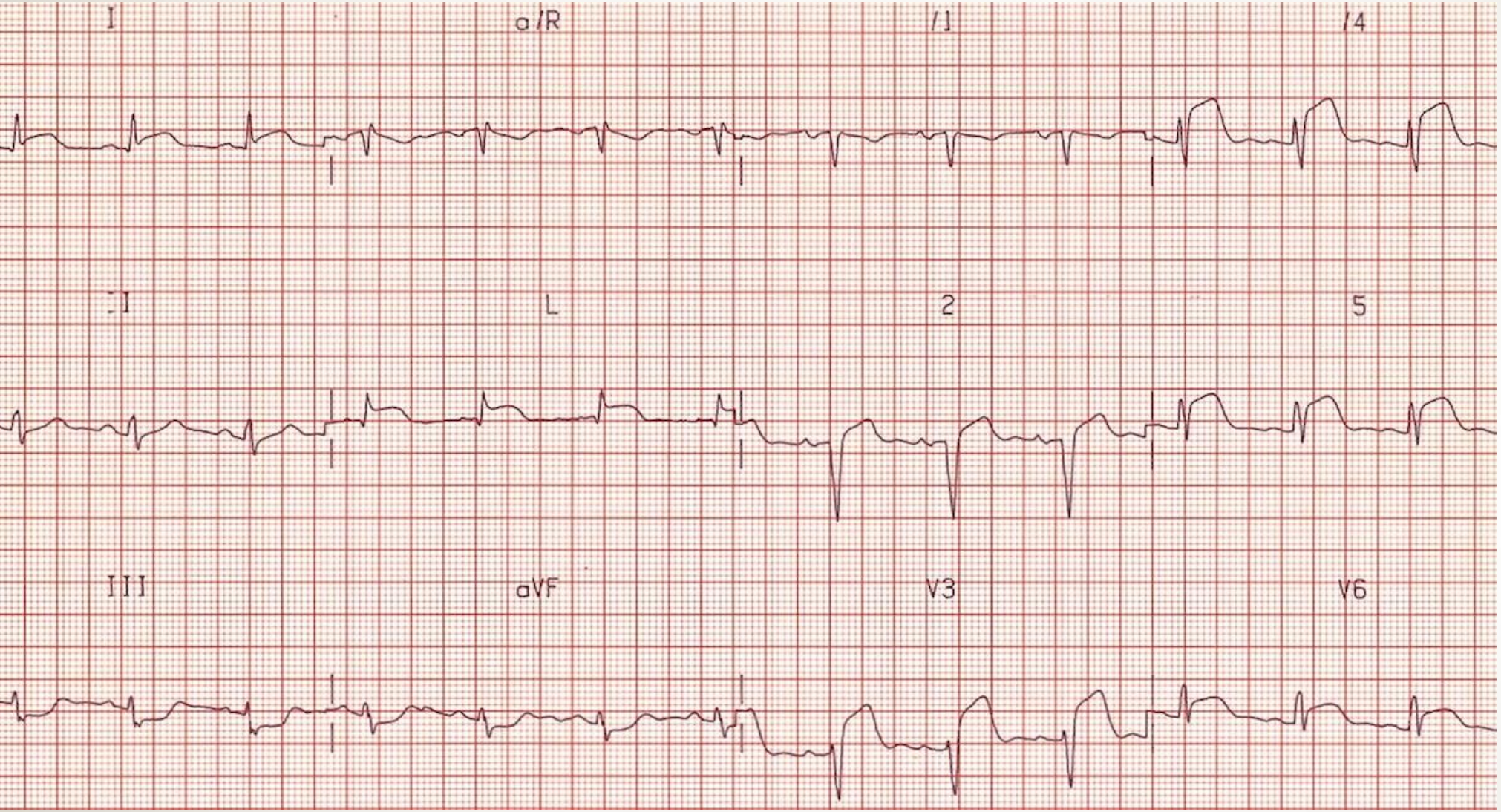
Myocardial Infarction/Ischemia

Signs of MI on ECG

CAUTION

- Almost every sign of infarction/ischemia seen on ECG is nonspecific.
- In general, the impression of an experienced clinician is more accurate in determining the presence/absence of acute coronary syndrome than an ECG is.
- Bottom line, almost never make decisions regarding care of ACS based on ECG findings alone.

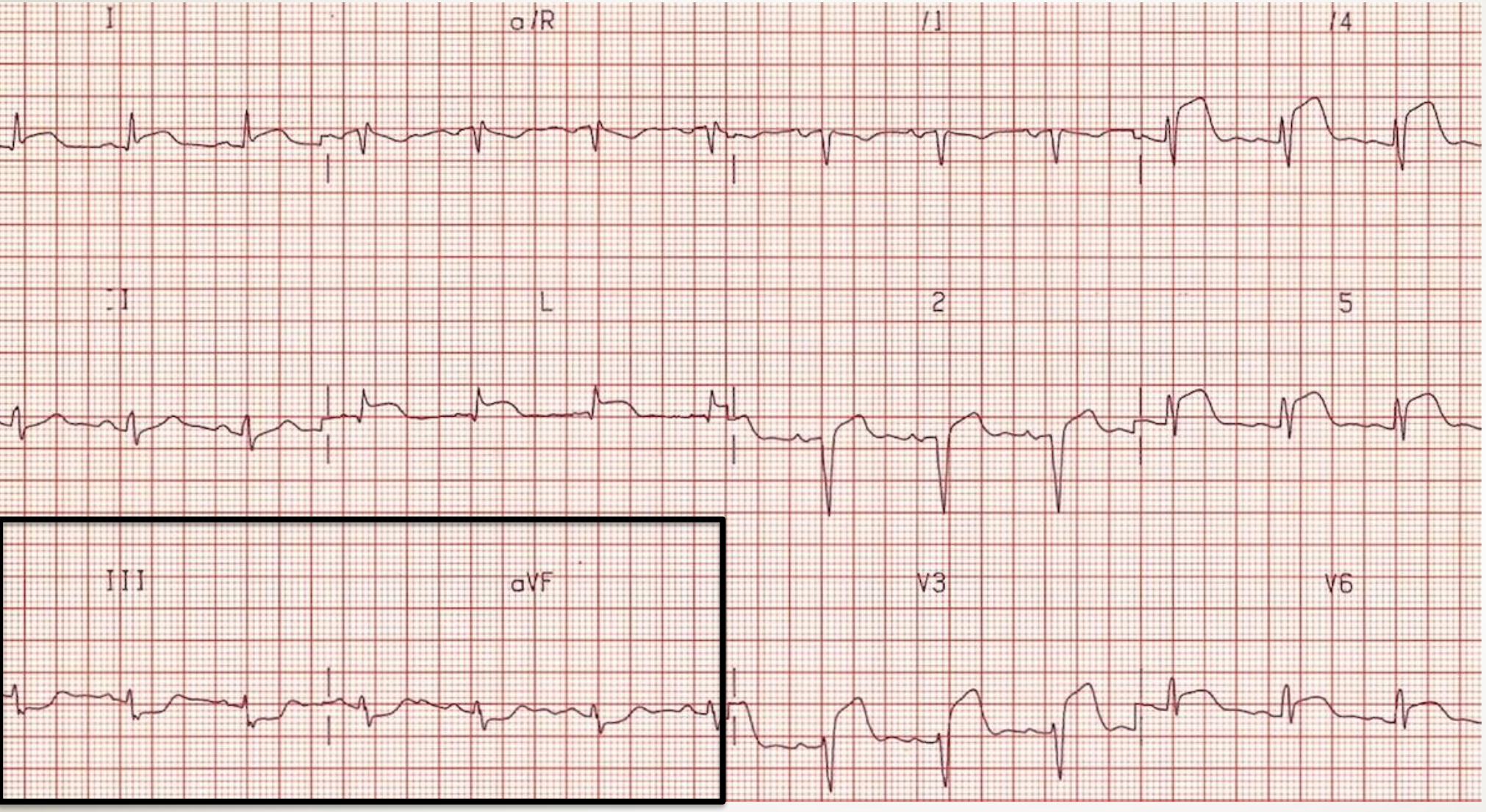
Signs of MI on ECG



ST Elevation

- J Point is elevated

Signs of MI on ECG



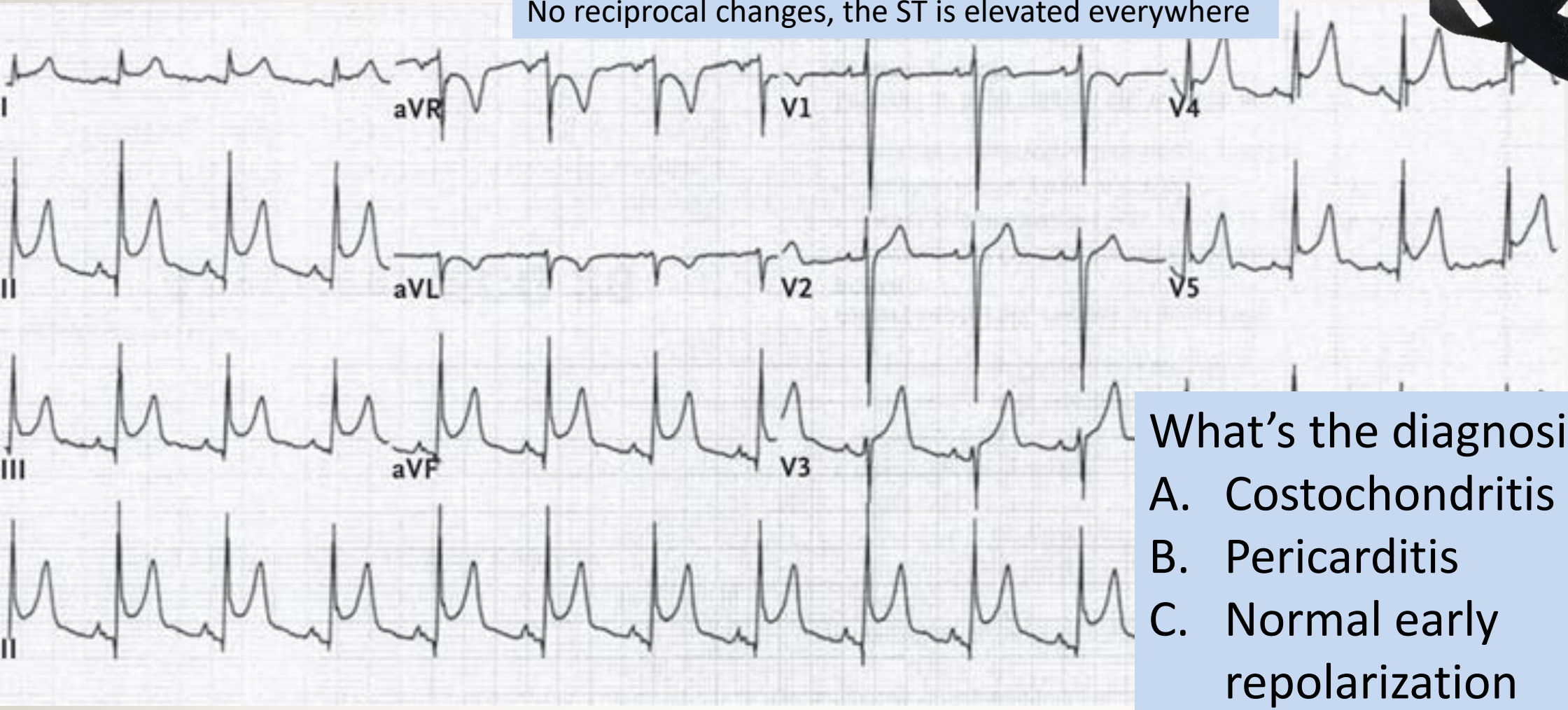
ST Elevation

- J Point is elevated

- Reciprocal ST depression

Signs of MI on ECG

No reciprocal changes, the ST is elevated everywhere

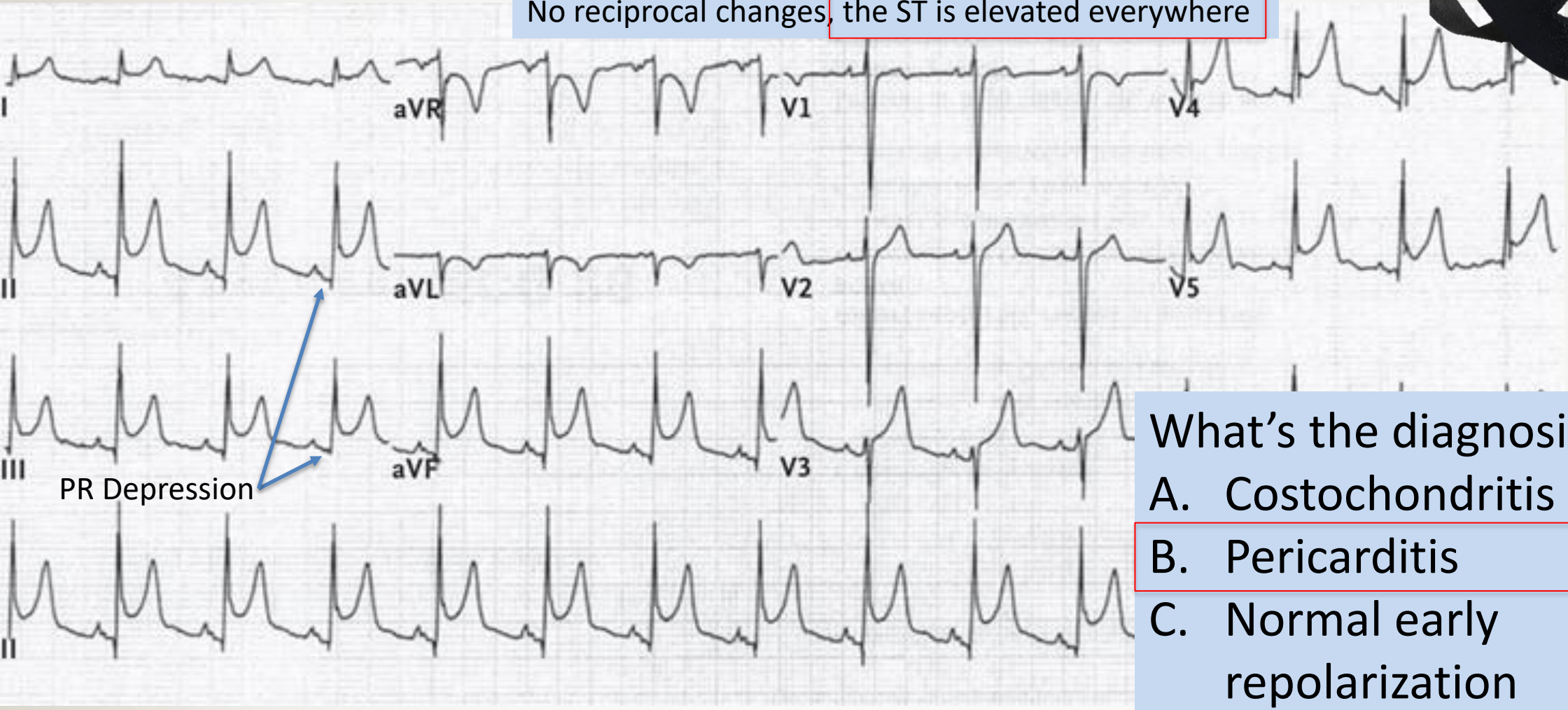


What's the diagnosis

A. Costochondritis
B. Pericarditis
C. Normal early repolarization

Signs of MI on ECG

No reciprocal changes, the ST is elevated everywhere



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A. Costochondritis
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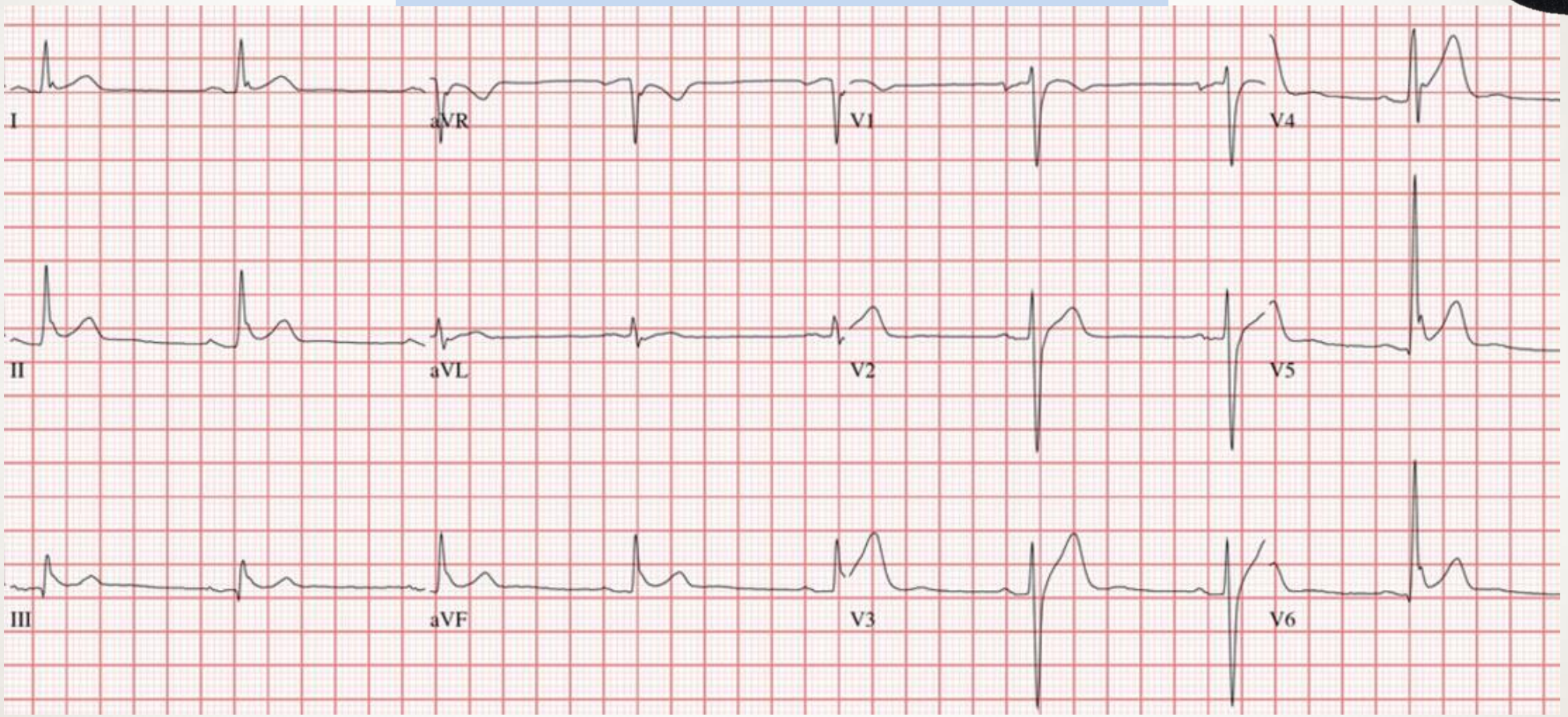
C. Normal early repolarization

Signs of MI on ECG

No J point Elevation- Benign Early Repolarization
Commonly seen in young adults



Signs of MI on ECG

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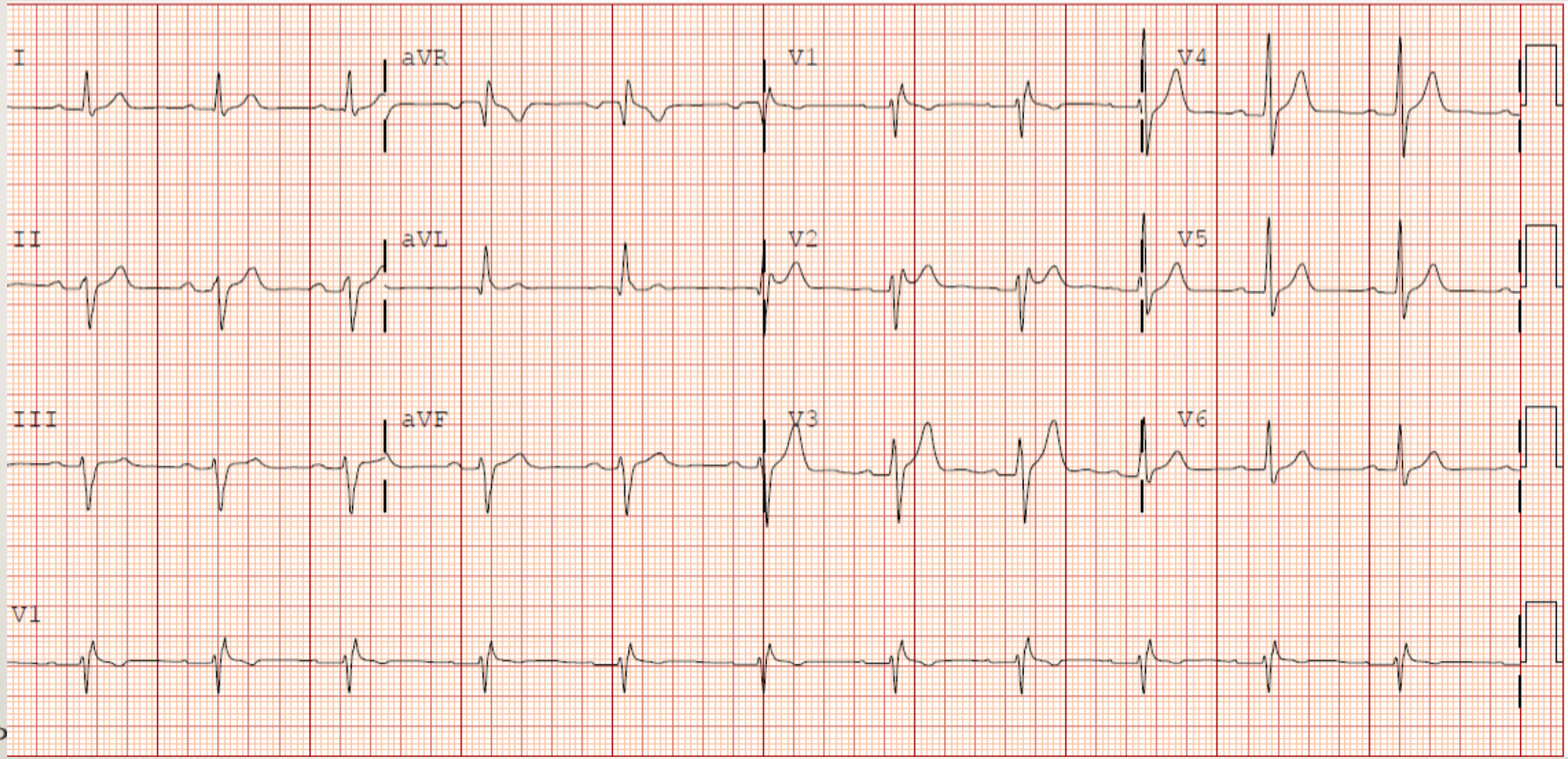

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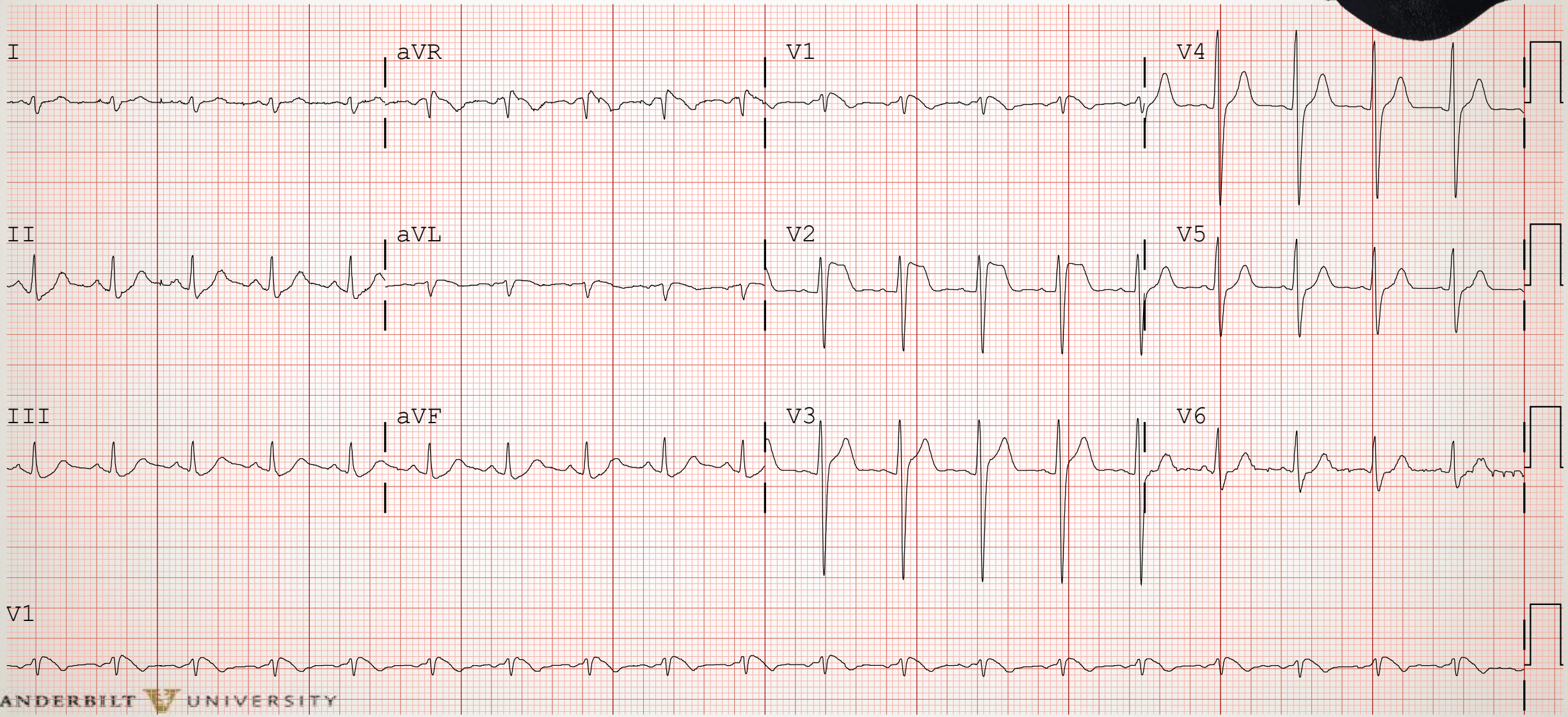
Brugada Syndrome



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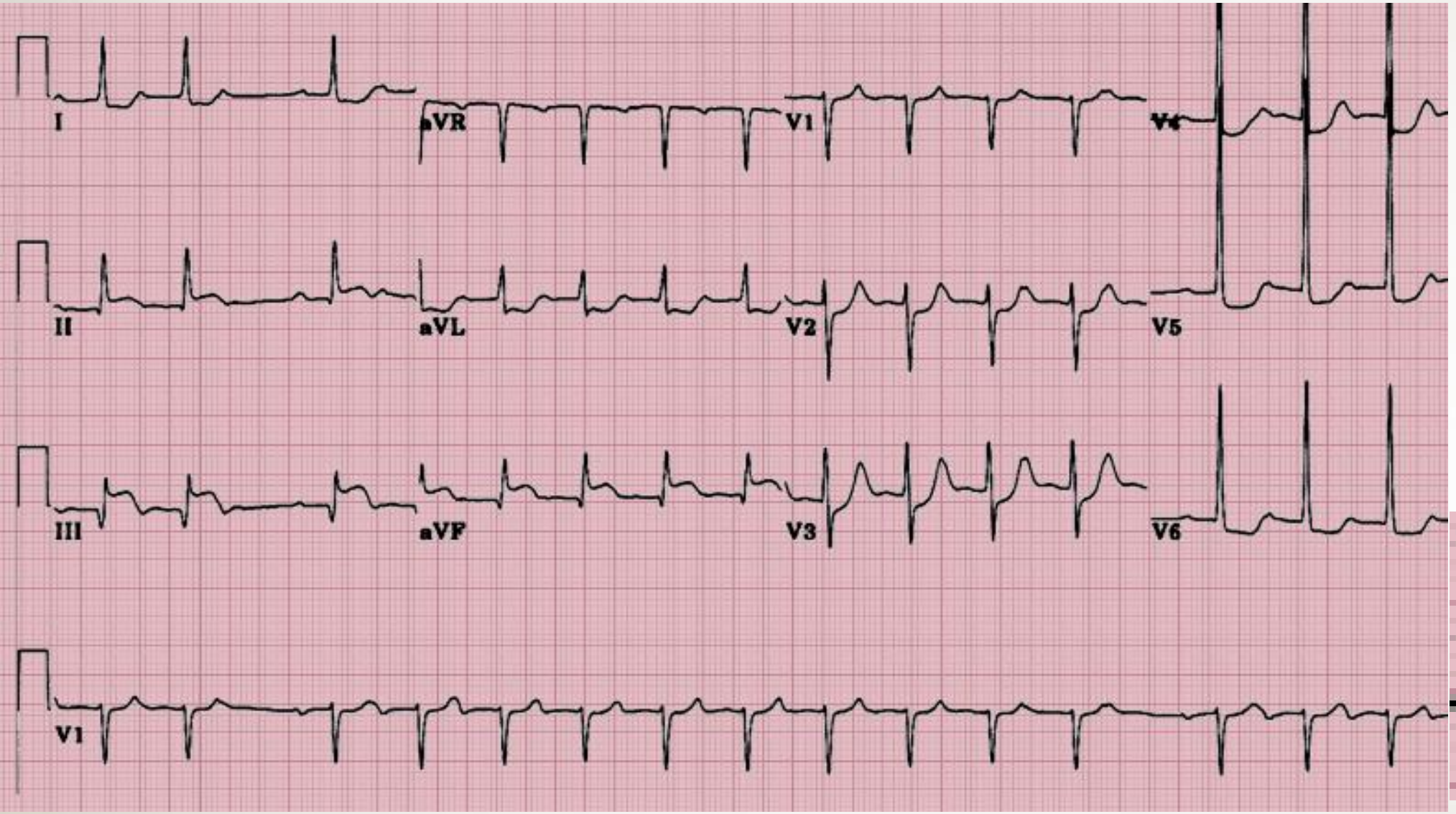
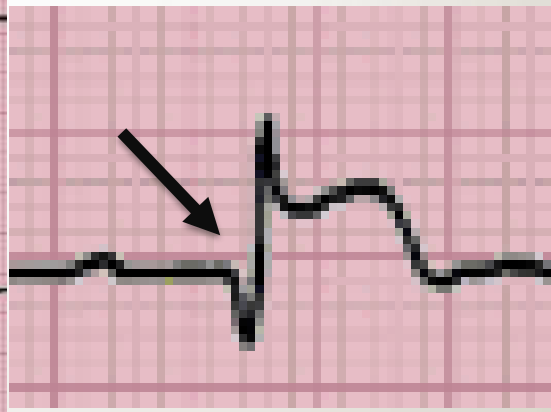
Signs of MI on ECG

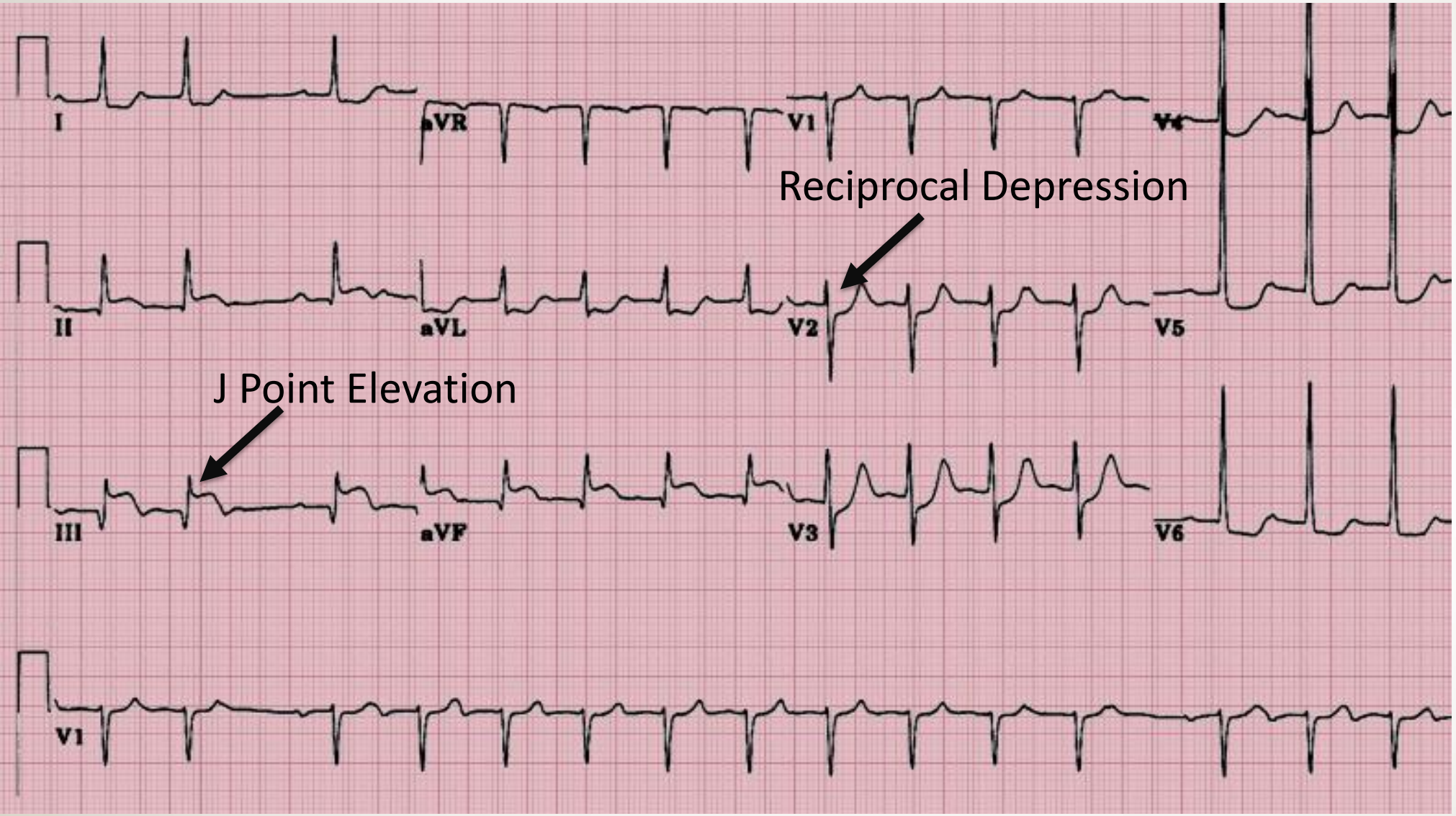


Q Waves

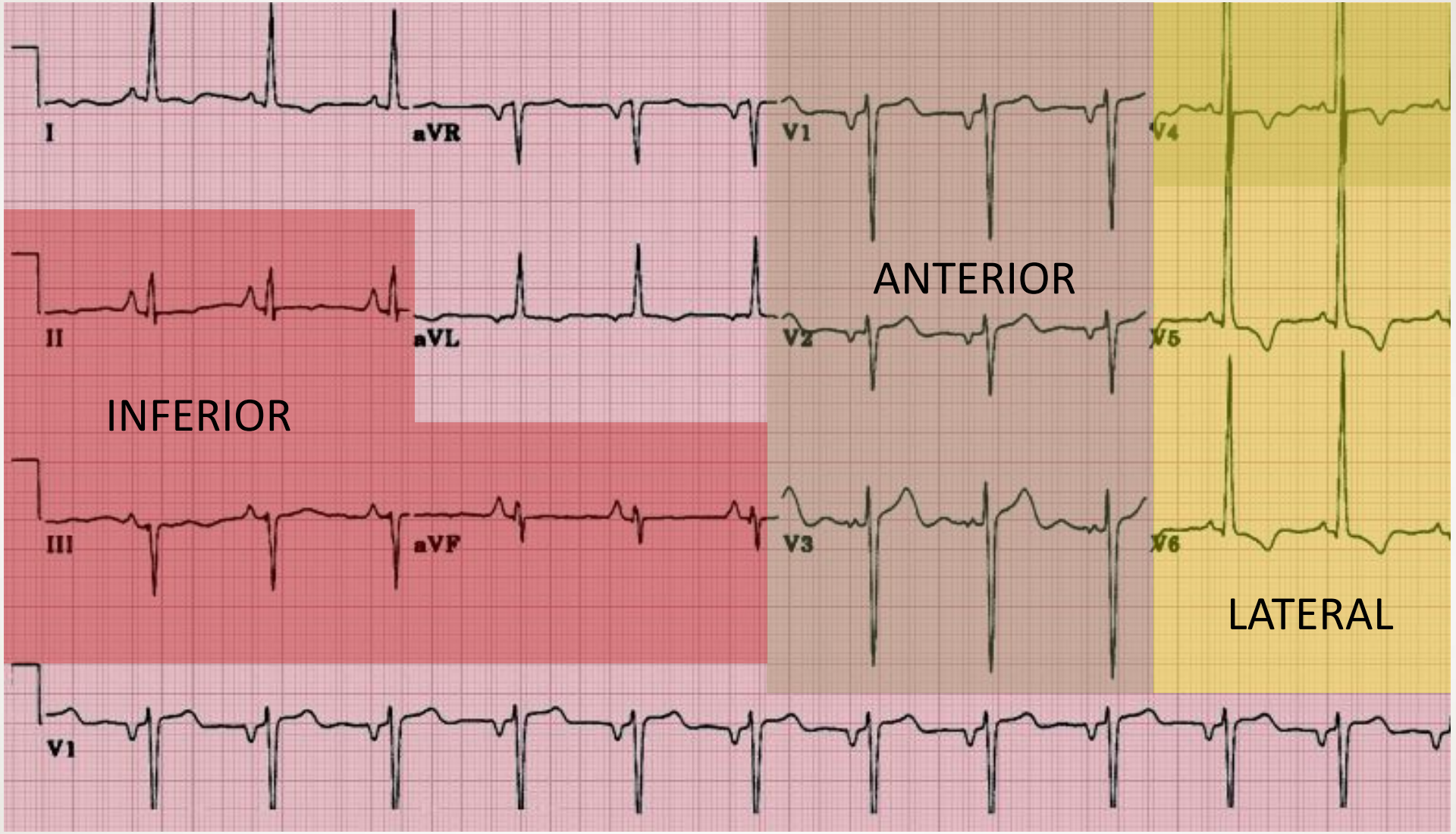
- Indicate transmural infarct
- Generally, >40ms wide and 2mm deep



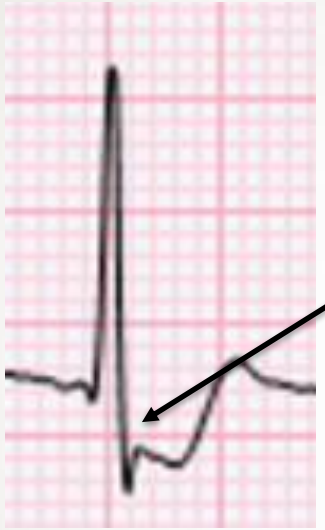
Signs of MI on ECG



MI Localization



Signs of Ischemia on ECG



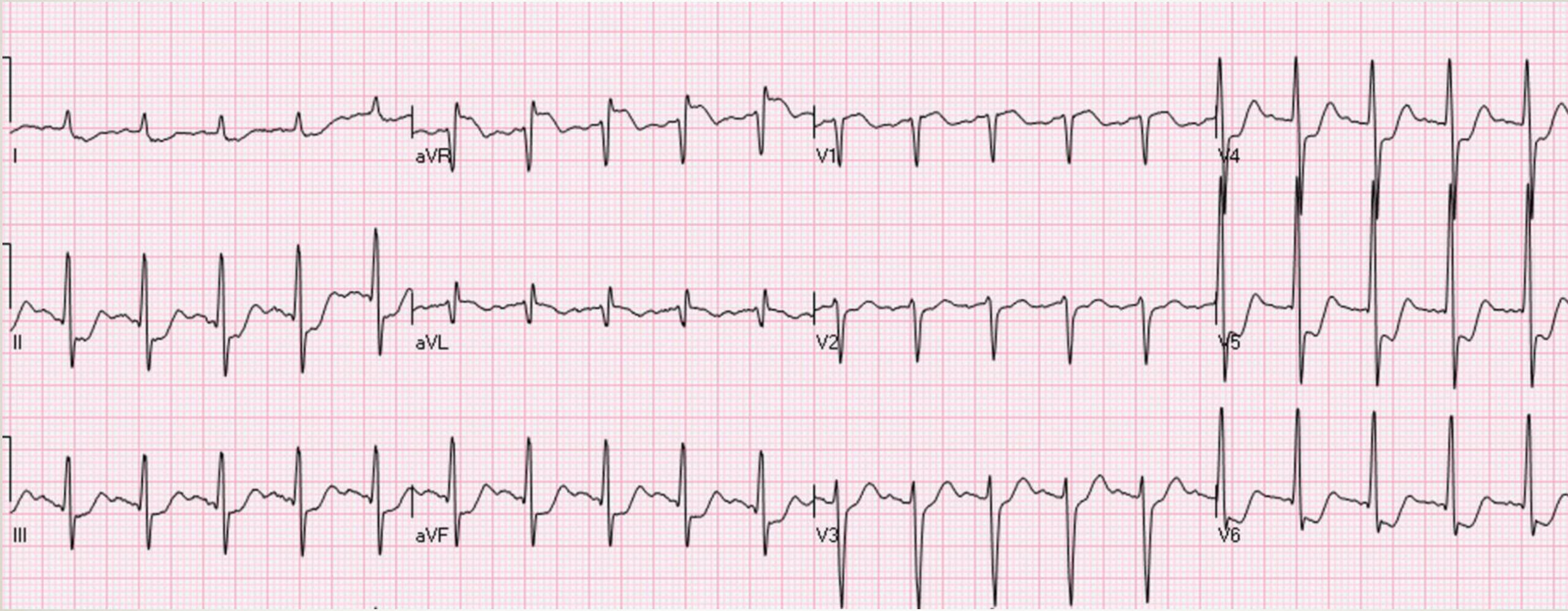
ST Depression

- J Point depression
- Downsloping ST segment

T- Wave Inversion

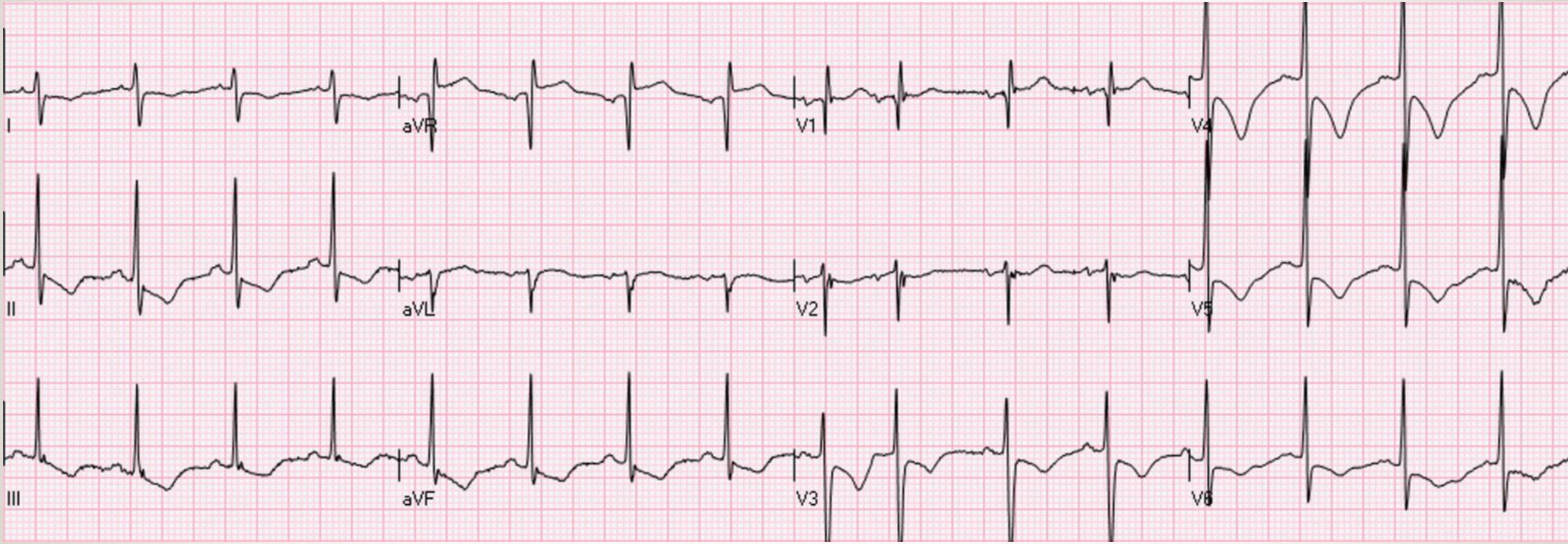
- CLINICAL CONTEXT

Signs of Ischemia on ECG



Knotts et al. J Electrocardiology 2013

Signs of Ischemia on ECG



Knotts et al. J Electrocardiology 2013

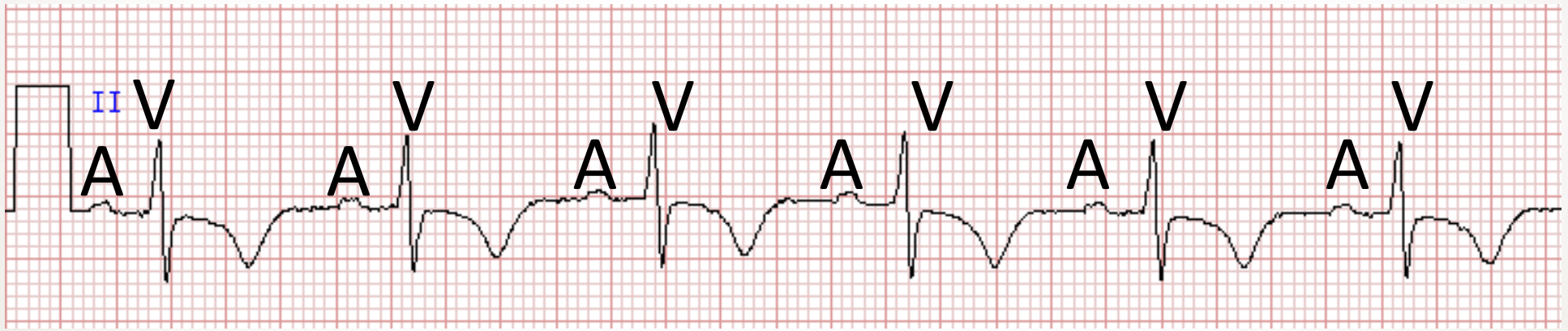
Arrhythmias

Rhythm

- The first step to rhythm identification is to determine if the rhythm is regular or irregular.
- Regular means a repetitive RR interval

Rhythm

- The second step to rhythm identification is to identify all evidence of atrial and ventricular activity.



Rhythm

- Third, is the QRS wide or narrow?

Rhythm

- Fourth, is the P wave upright in lead II?

Rhythm

- The first question to ask now is:

  Is this Sinus rhythm?

  – Regular?

  – 1:1 AV conduction?

  – Narrow QRS?

  – Upright P in lead II?

  If the answer to all four of these is yes, the rhythm is most likely sinus.

Rhythm

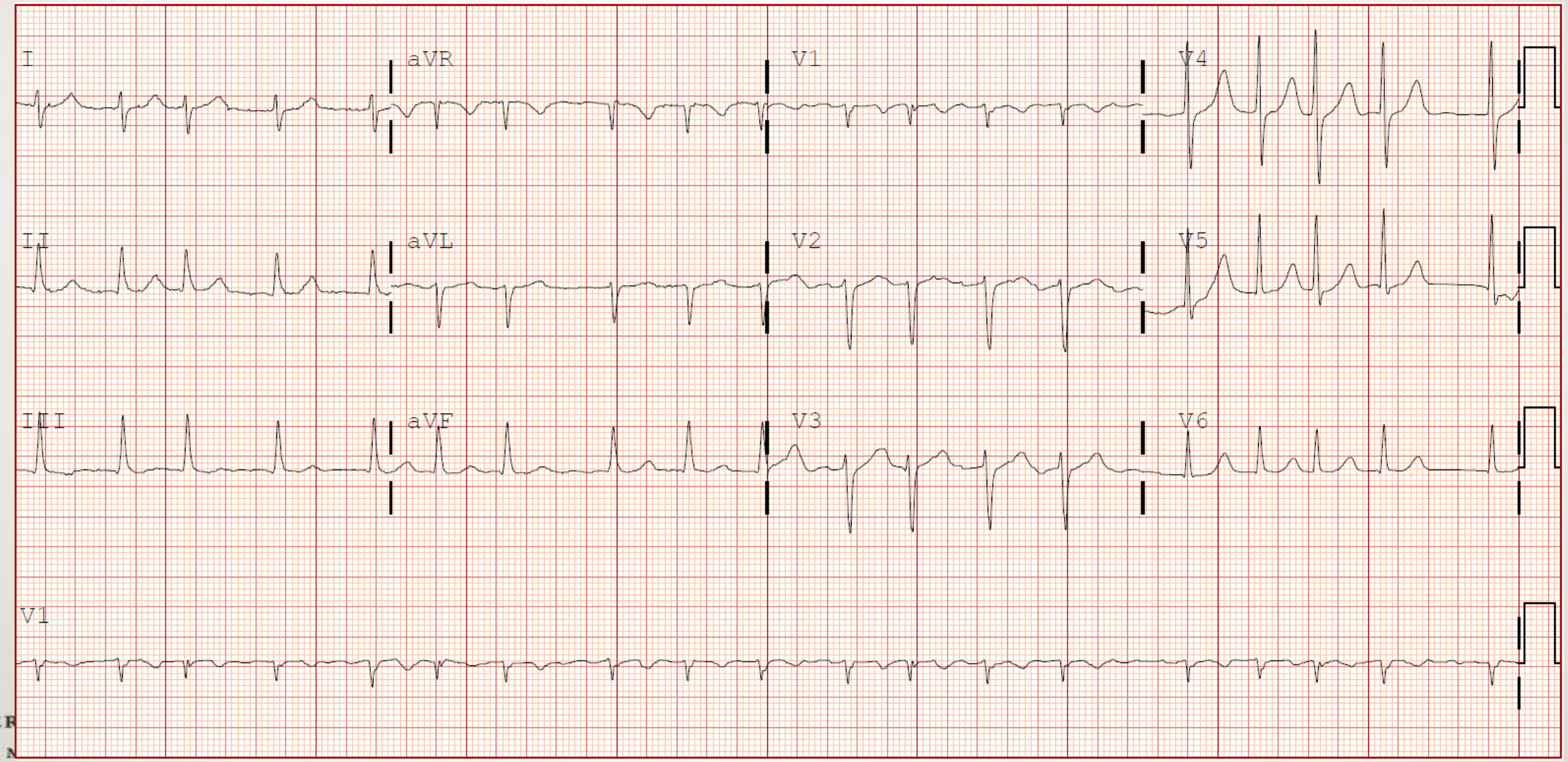
- If the rhythm doesn't seem to be sinus the information we have gathered allows us to build a few groups of rhythms.
- We will go through the causes of irregular and regular arrhythmias.

Irregular Rhythms with 1:1 AV relationship

1. Sinus Arrhythmia- benign rhythm where the P to P interval varies slightly with inspiration. The rhythm will be only slightly irregular.
2. Multifocal atrial tachycardia- Irregular, narrow complex tachycardia with multiple P-wave morphologies present.

Irregular Rhythms with no clear atrial activity

Atrial Fibrillation

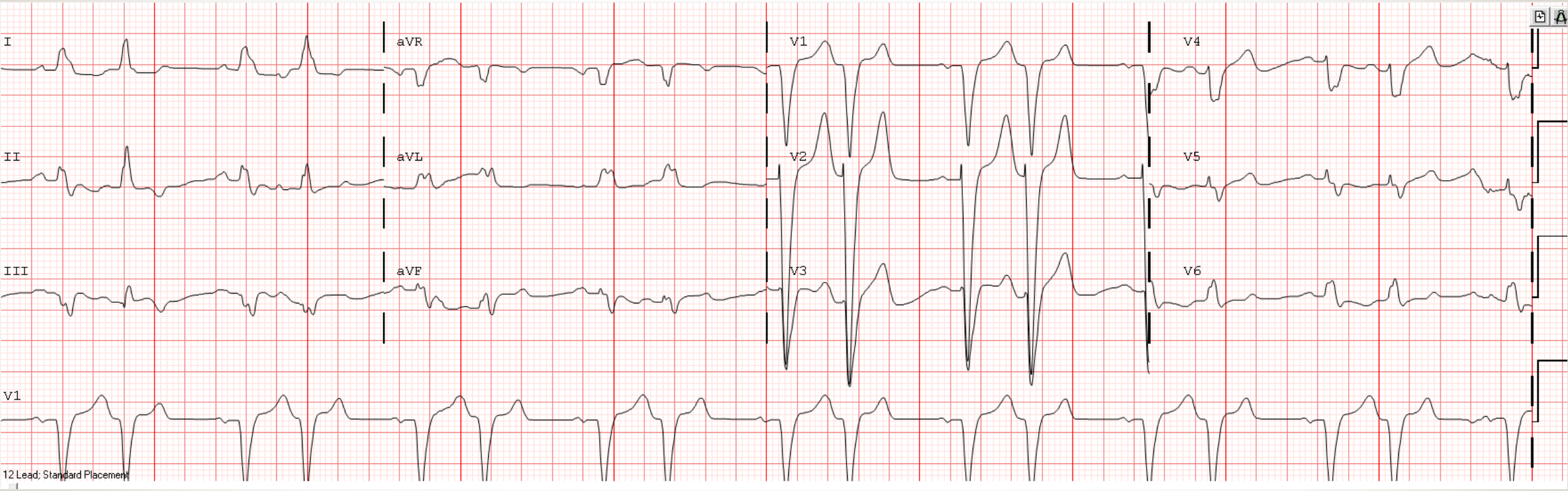


Irregular Rhythms with Wide QRS

1. Any Irregular rhythm with coexisting BBB
2. Ventricular Fibrillation- Very wide, chaotic rhythm, **only seen in cardiac arrest**.

Irregular Wide Complex tachycardia

Prior ECG


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
12 Lead; Standard Placement

Irregular Wide Complex tachycardia
Atrial Fibrillation

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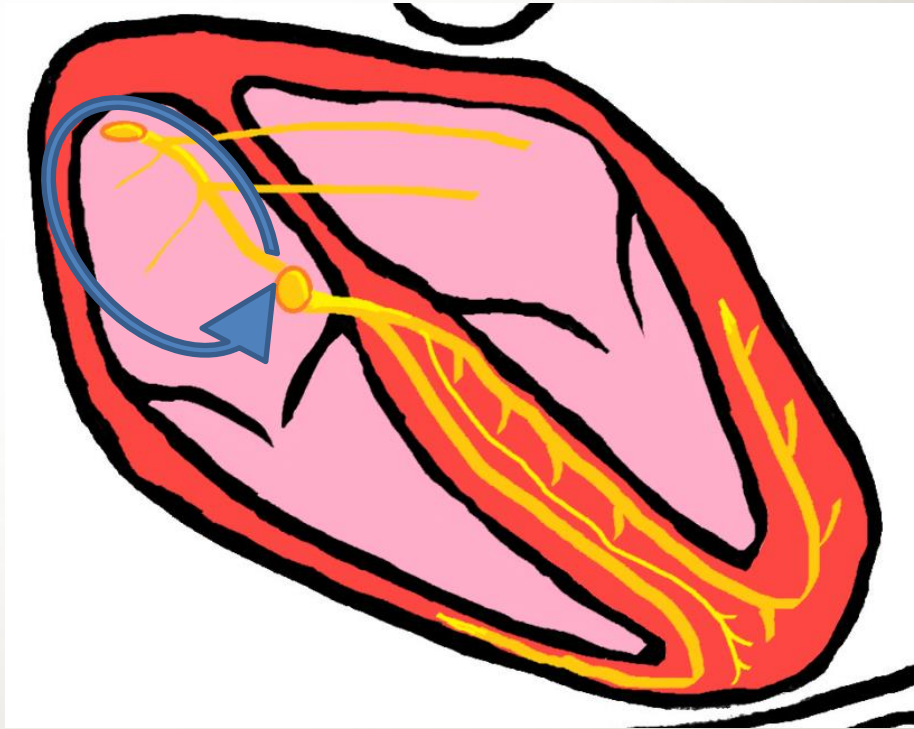
Regular narrow QRS Tachycardia (SVT)

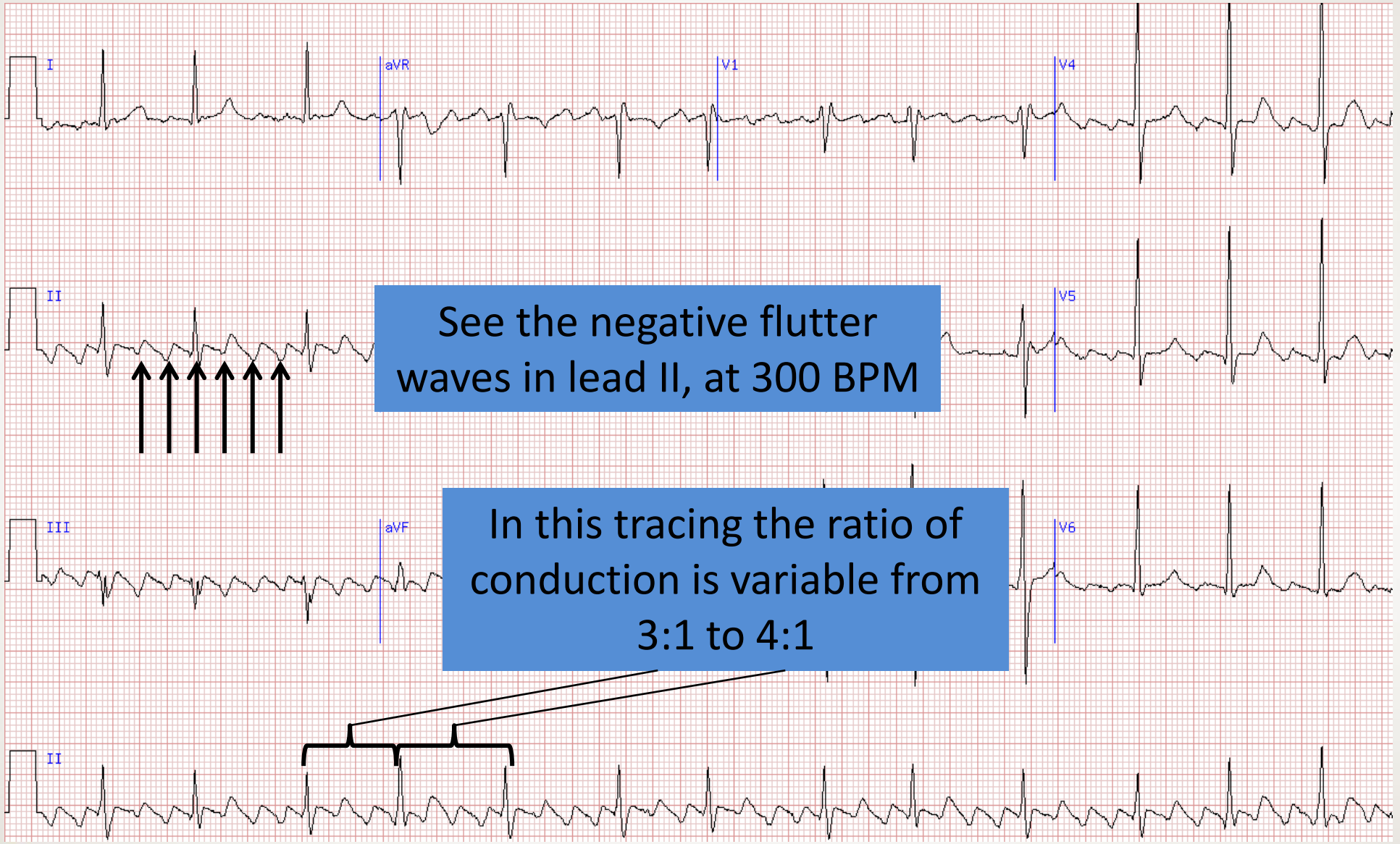
- Atrial Tachycardia
  - Sinus
  - Ectopic Focus
  - Flutter
- AV Nodal Reentrant Tachycardia
- AV Reentrant/Reciprocating Tachycardia

Atrial Flutter

- This rhythm results from a reentrant loop within the right atrium.
- The loop reciprocates at 300BPM
- Typically every other atrial depolarization conducts, resulting in a HR of 150 BPM. Slower patterns are also possible like 3:1 or 4:1.



Atrial Flutter

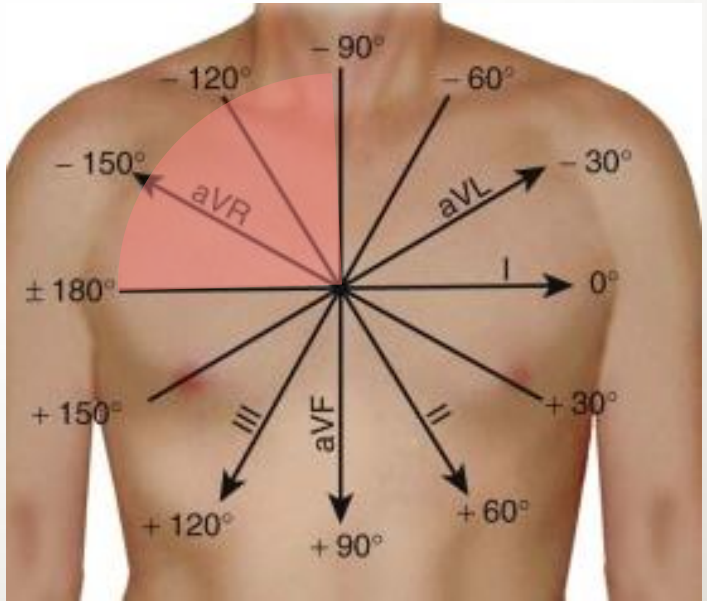


Regular Wide QRS Tachycardia

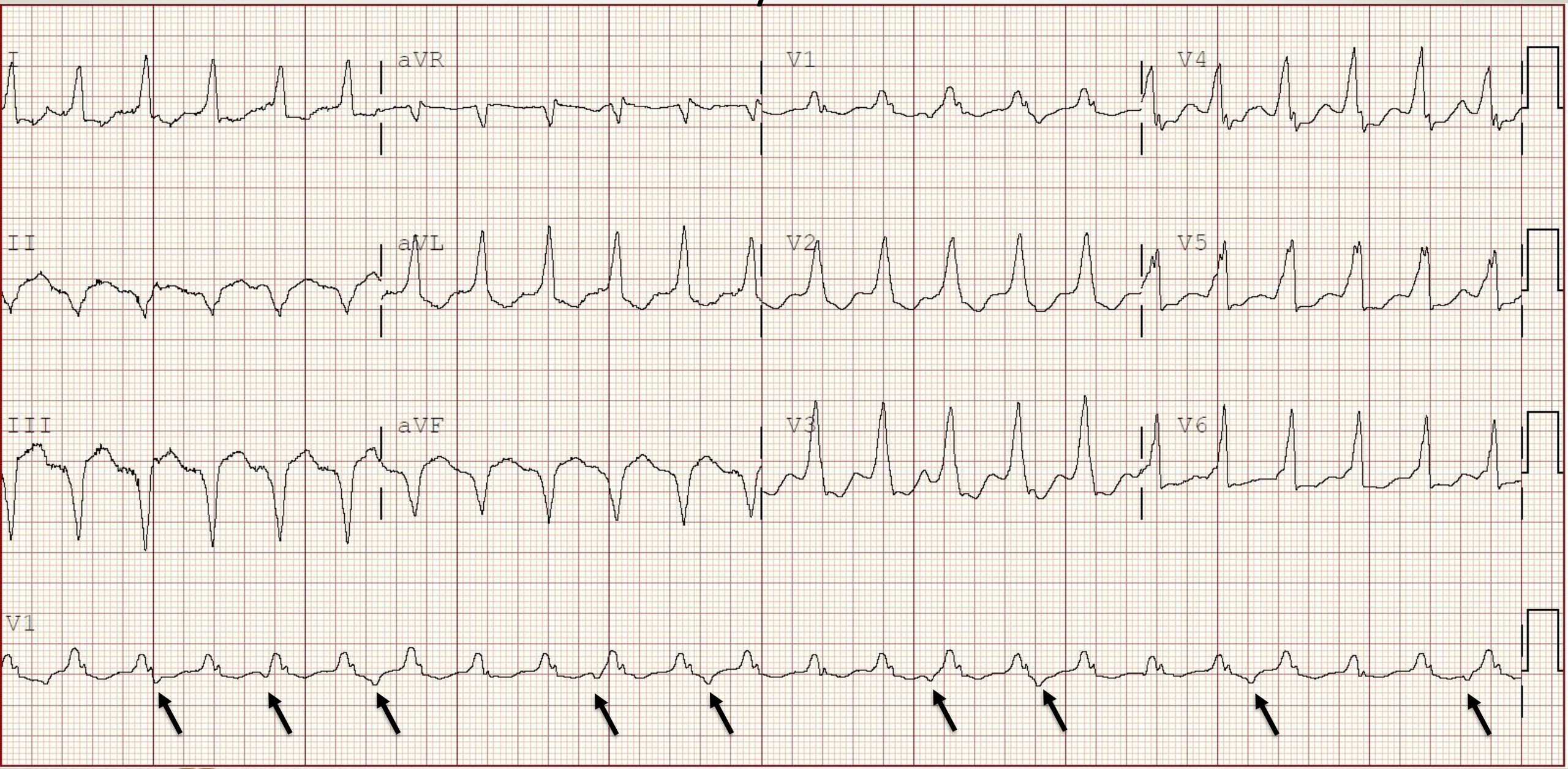
1. Ventricular Tachycardia
2. Any regular rhythm with aberrant conduction (underlying bundle branch block or pre-excitation/WPW)

Regular Rhythms

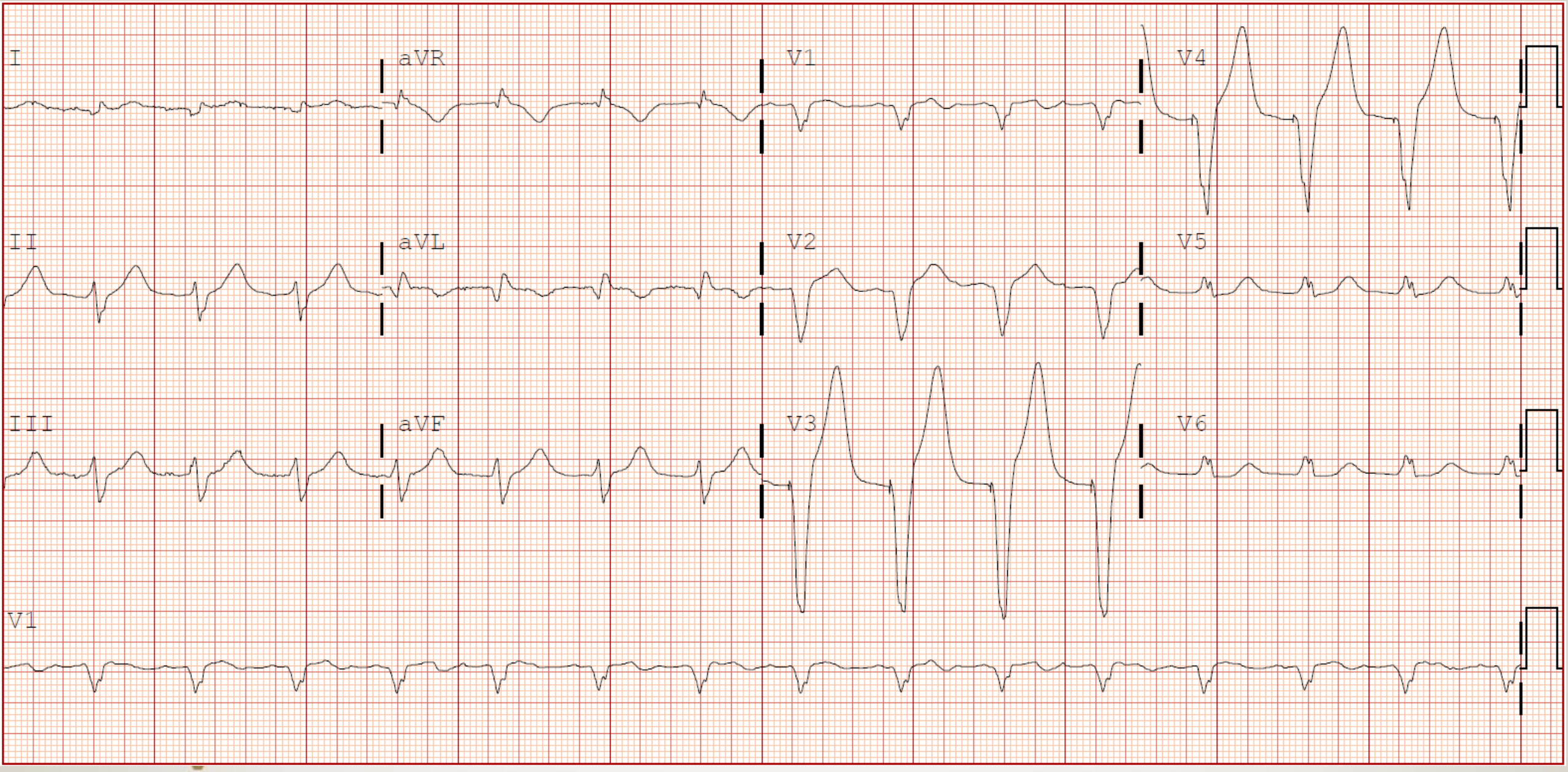
- Many systems have been described for distinguishing VT from aberrancy. Here are a few simple points that point to VT rather than aberrancy.
  - AV dissociation
    - P waves, Fusions, and Captures
  - QRS > 160mS
  - NW axis
  - Doesn't look like BBB
  - Precordial Concordance



VA Dissociation / Precordial Concordance



Pacing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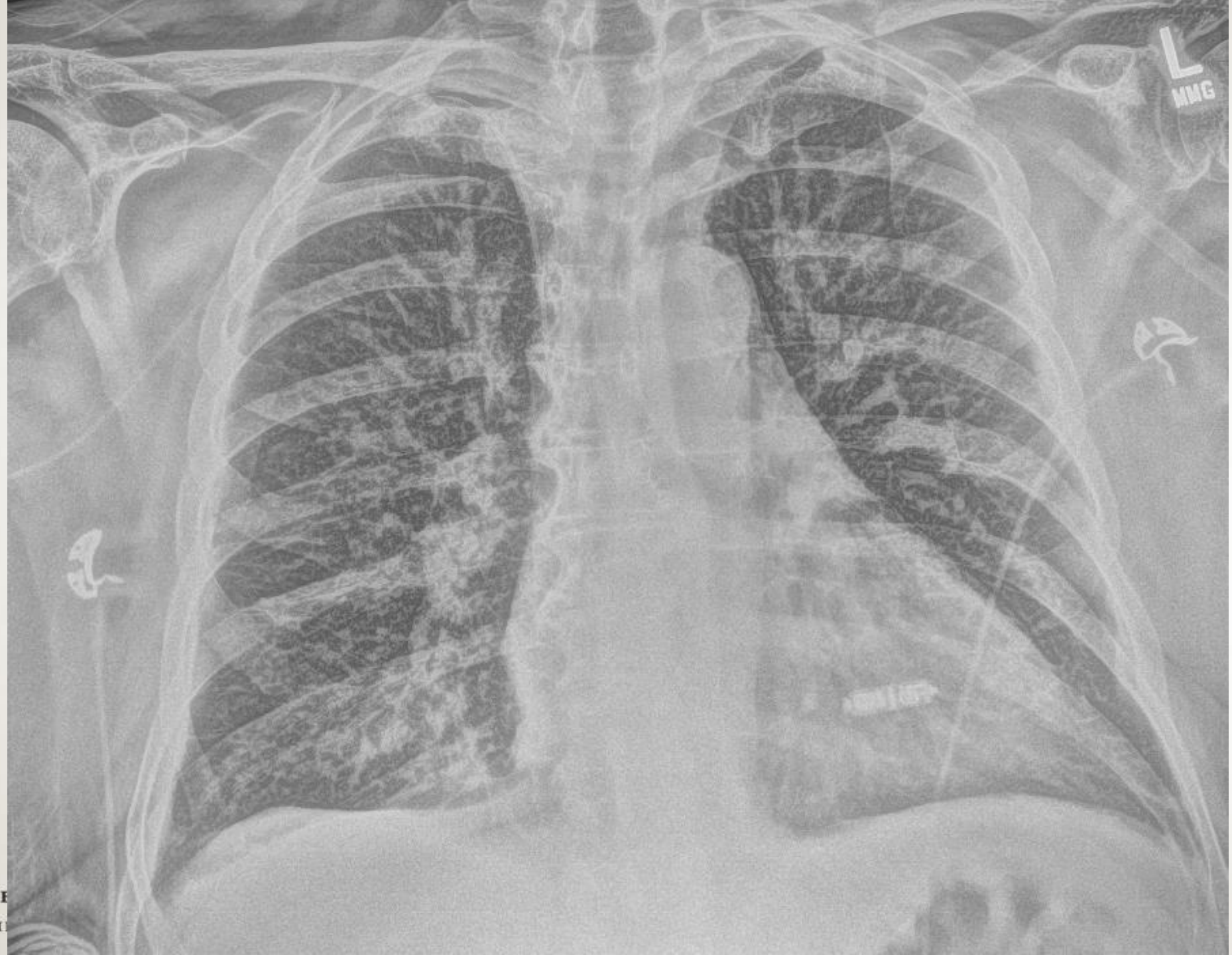
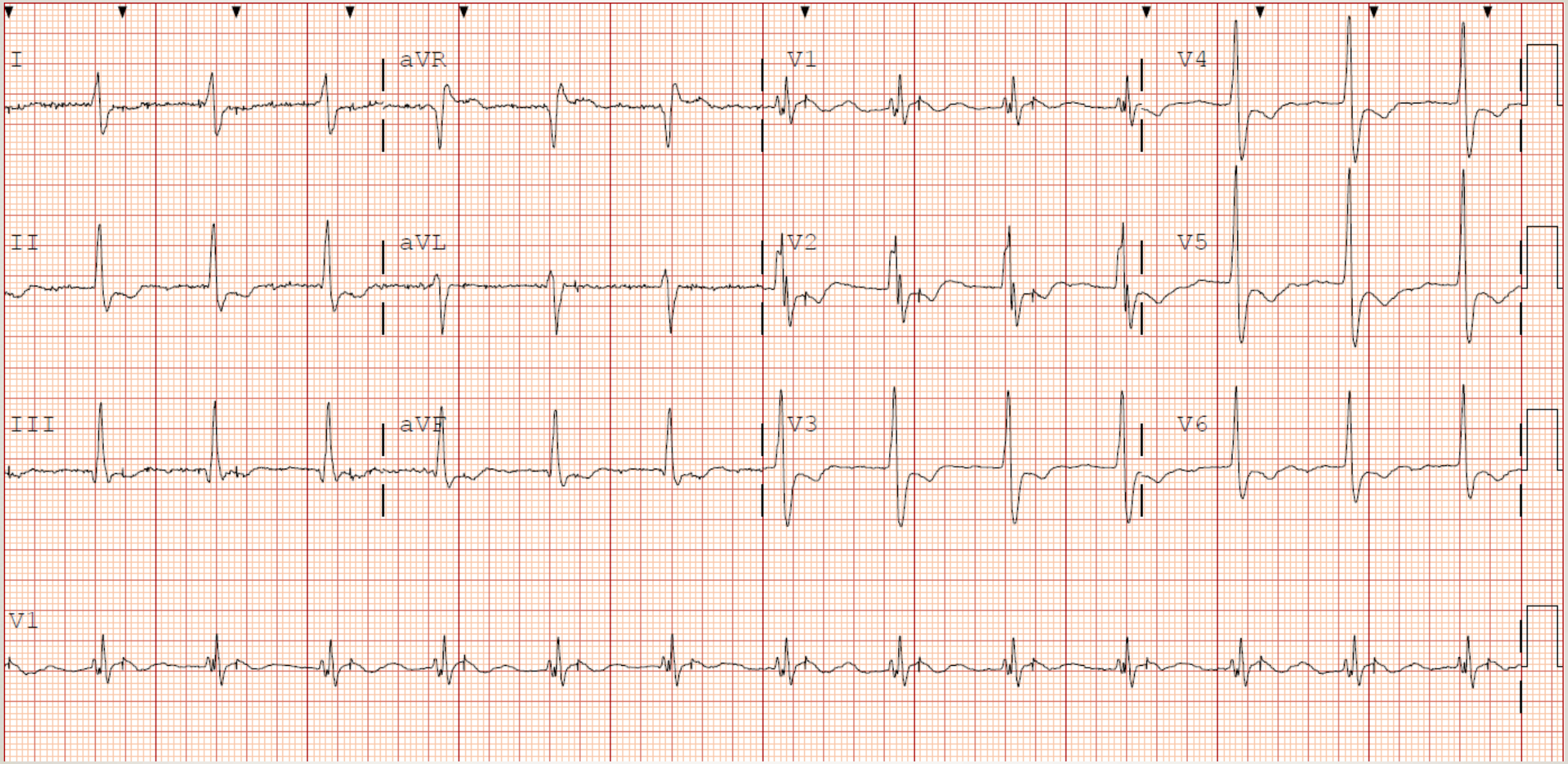
V1


L
MMG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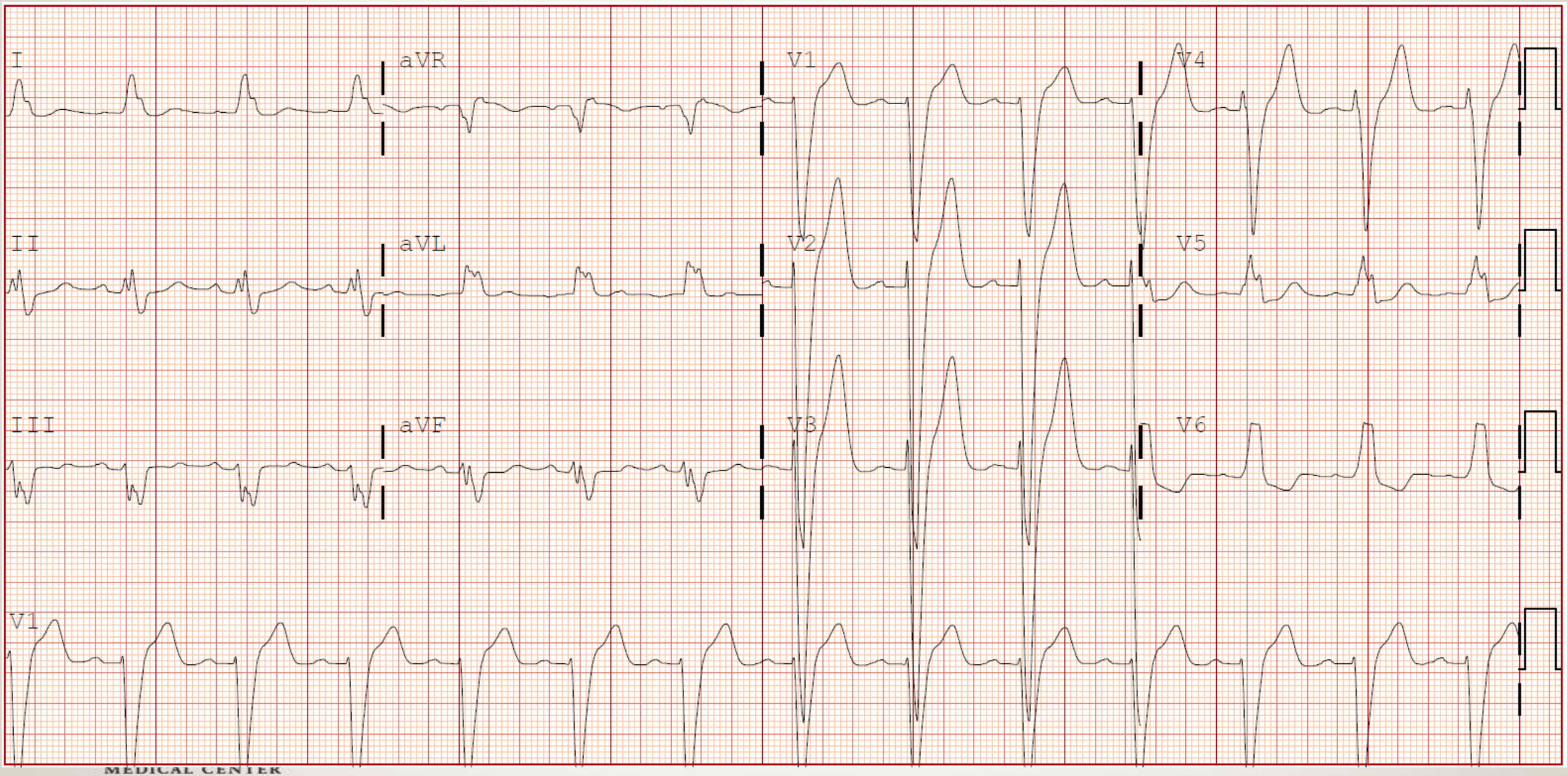
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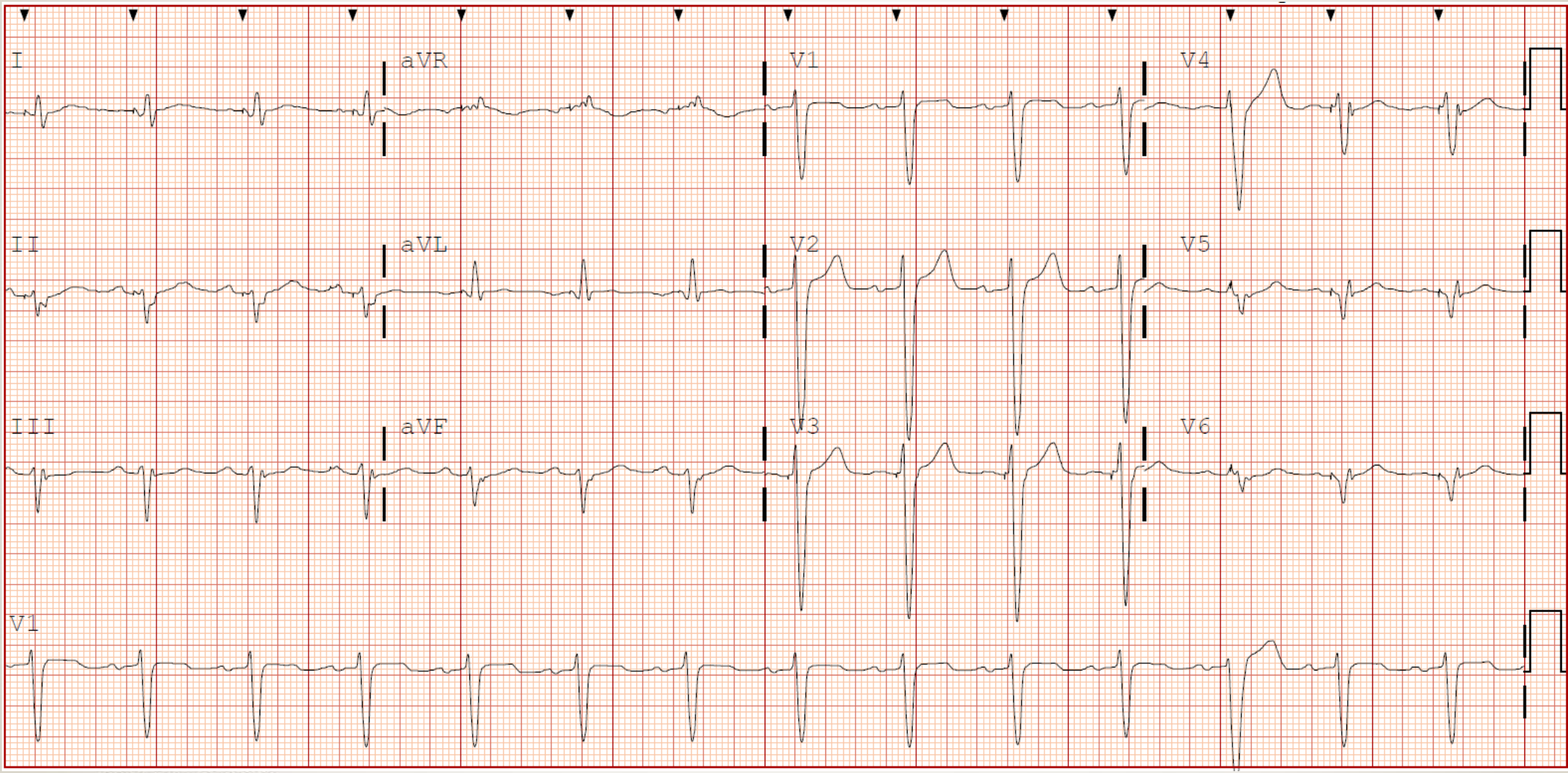

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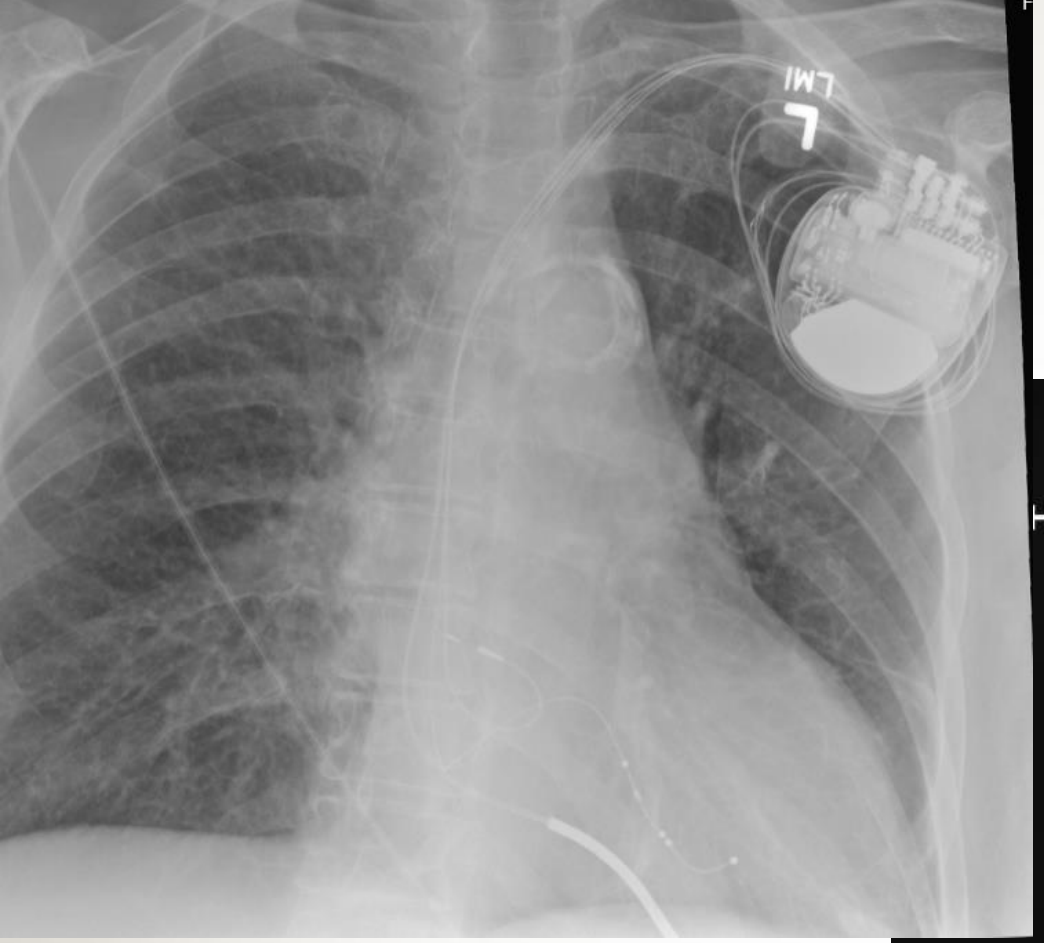

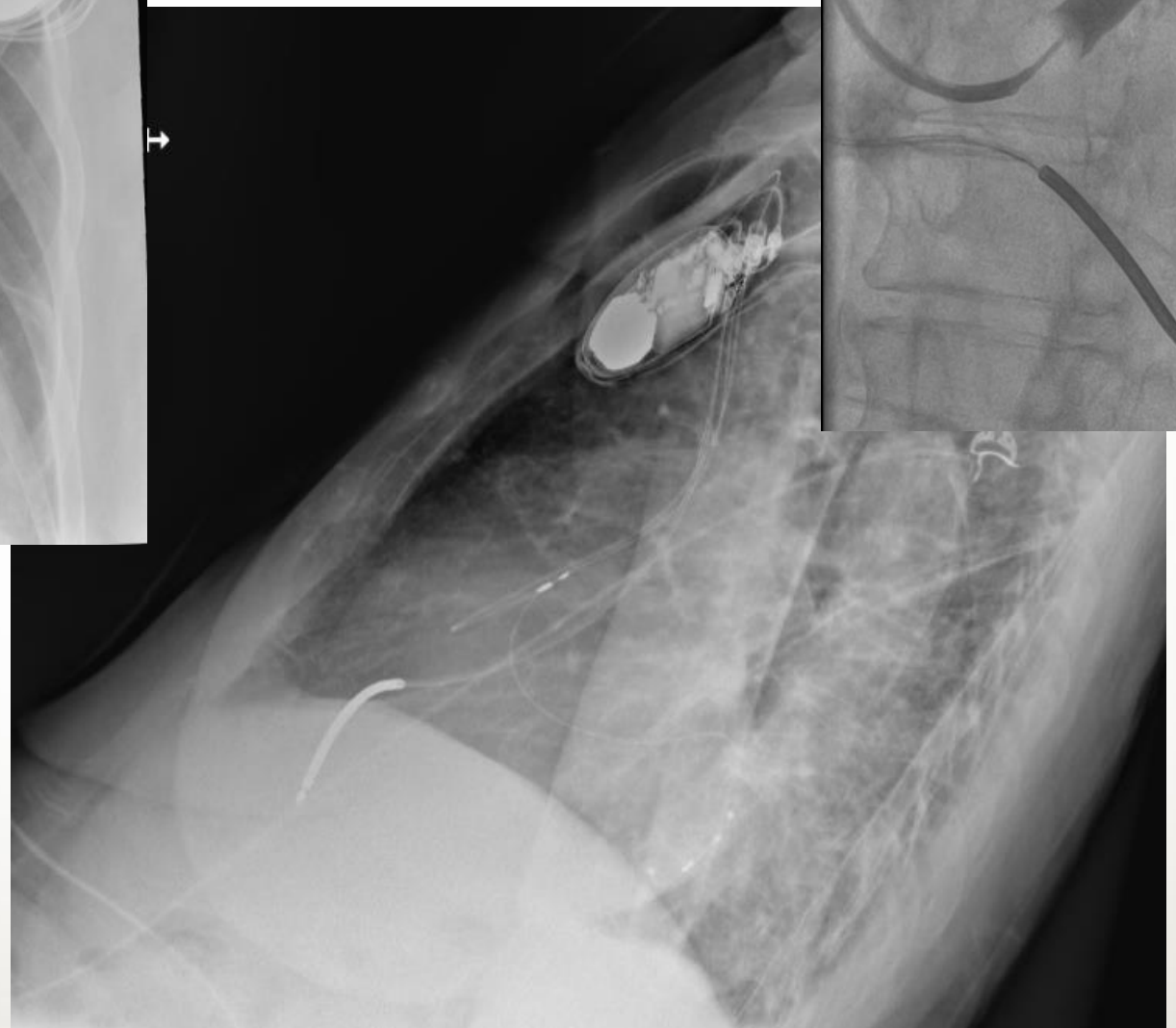

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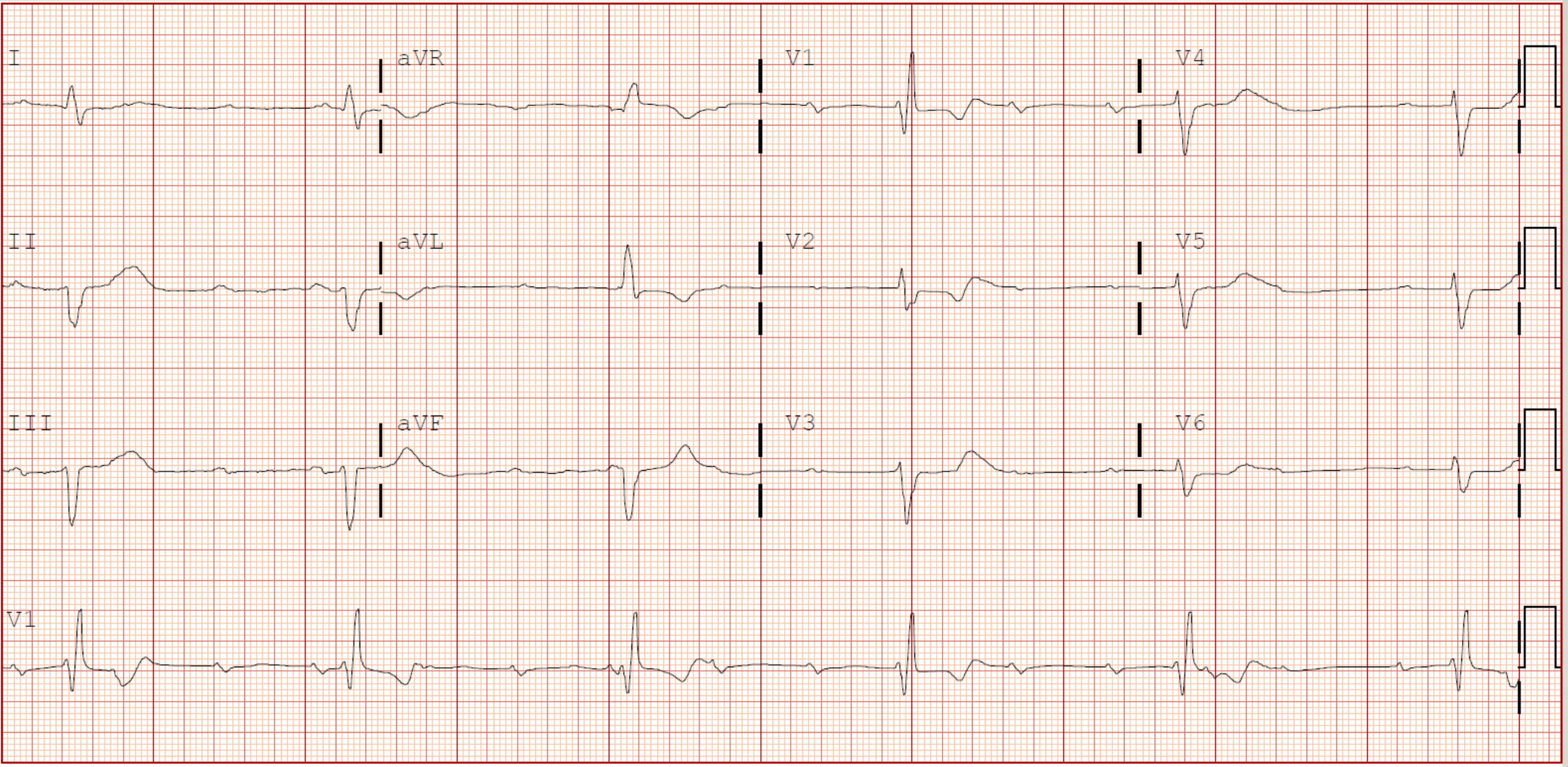
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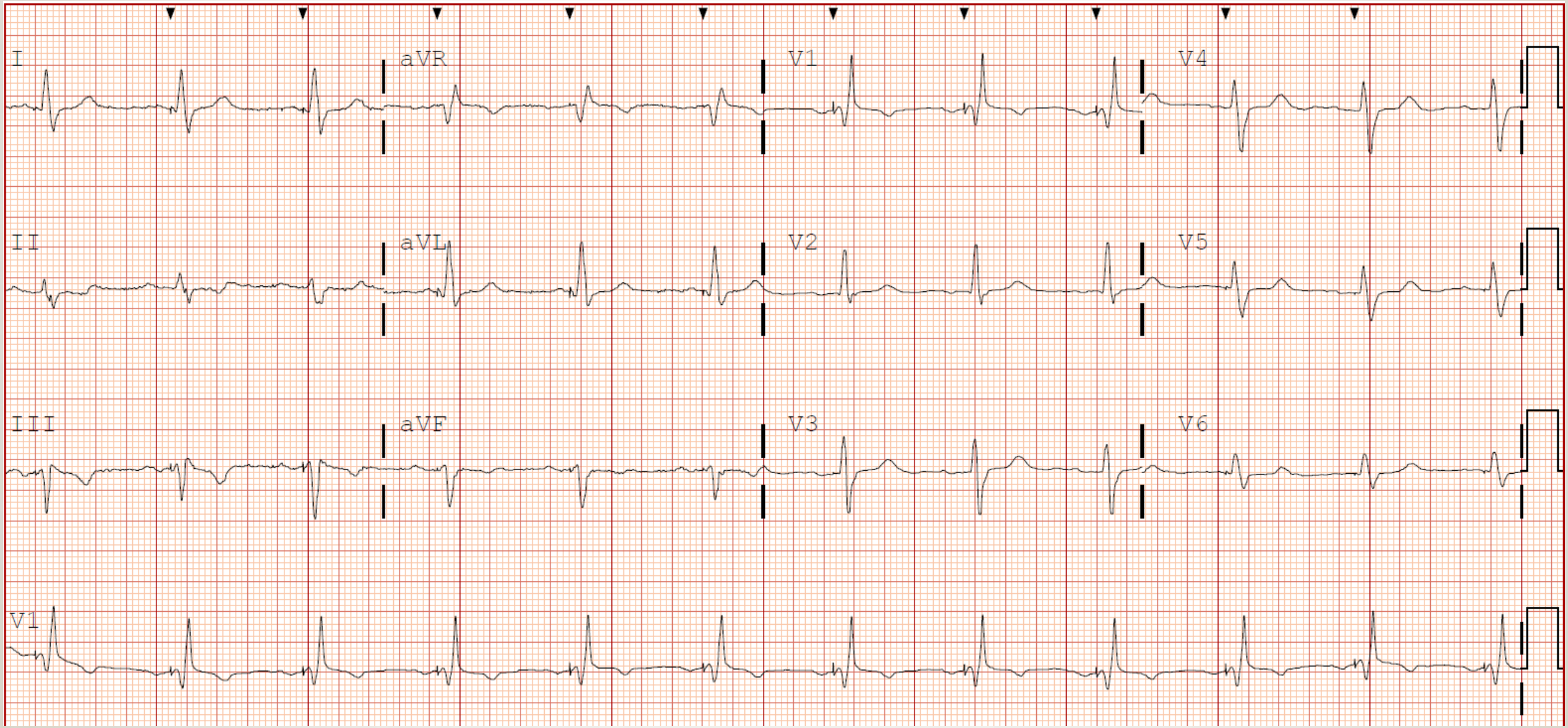
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Questions?

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