Common ECG and Telemetry Missteps :

Don’t Miss a beat !

Siva Soma, MD

Outline

- ECG Basics

- Common ECG Missteps
  - Old infarct
  - Heart blocks
  - Wide complex tachycardia
  - ST elevation on ECG

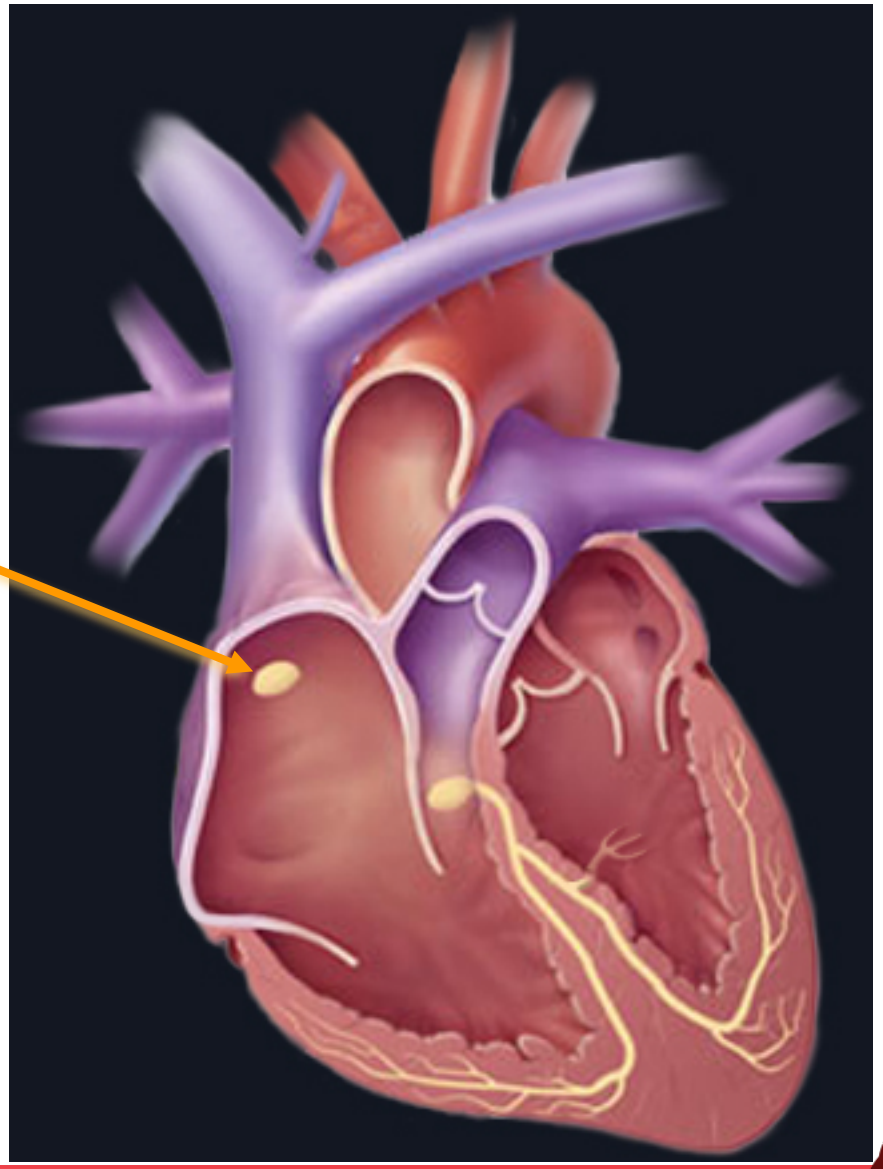
- Common Telemetry Missteps
  - Artifact
  - Inaccurate HR

Heart Beat Anatomy

Sinus Node
(SA Node)

The Heart's 'Natural Pacemaker'

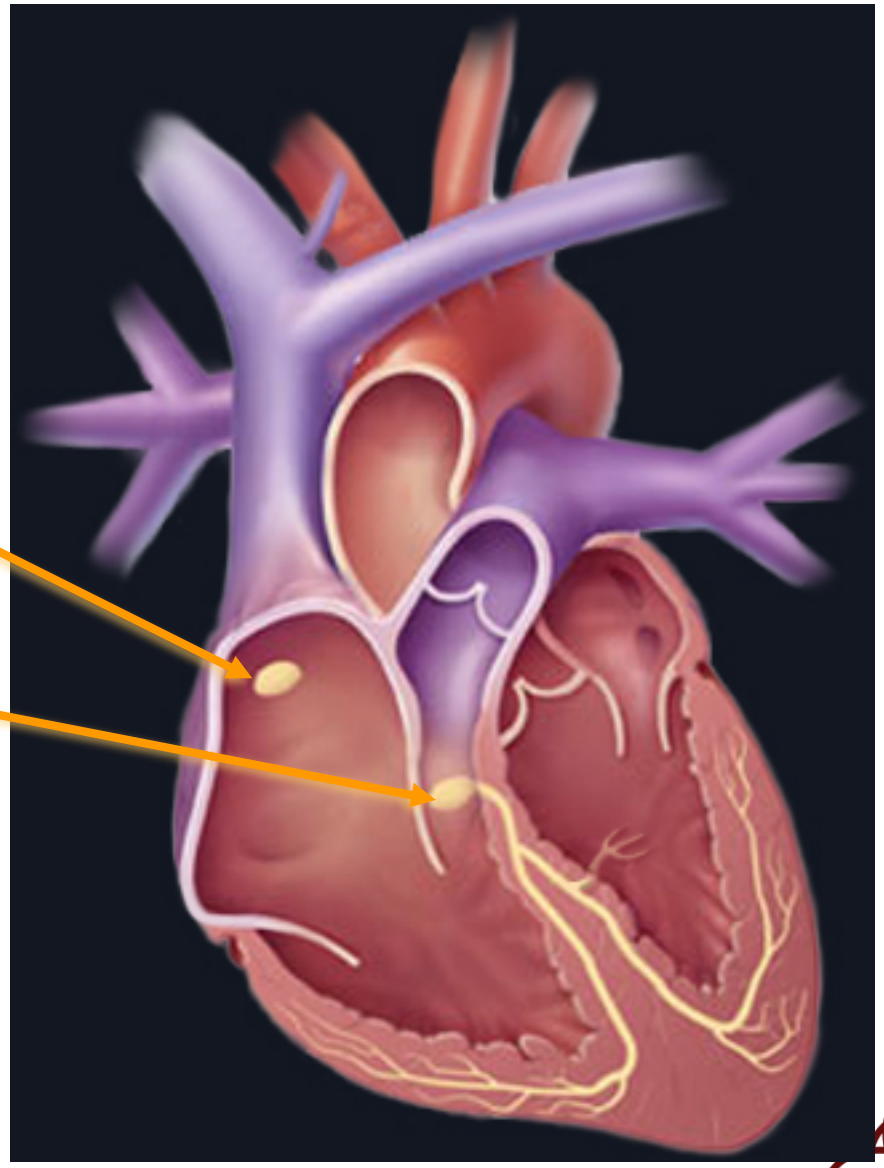
60 -100 BPM at rest



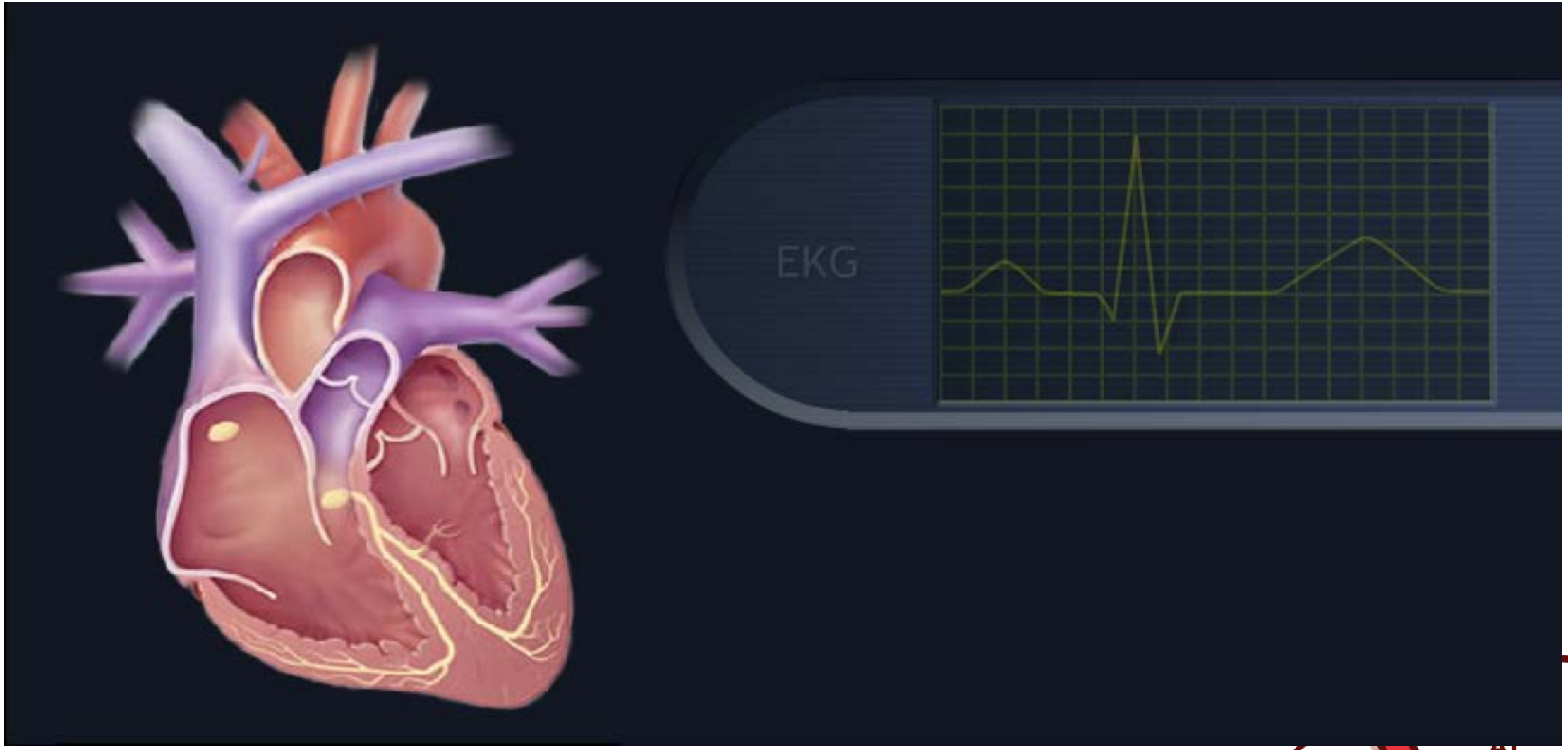
Heart Beat Anatomy

Sinus Node
(SA Node)

Atrioventricular Node (AV Node)



Normal Sinus Rhythm



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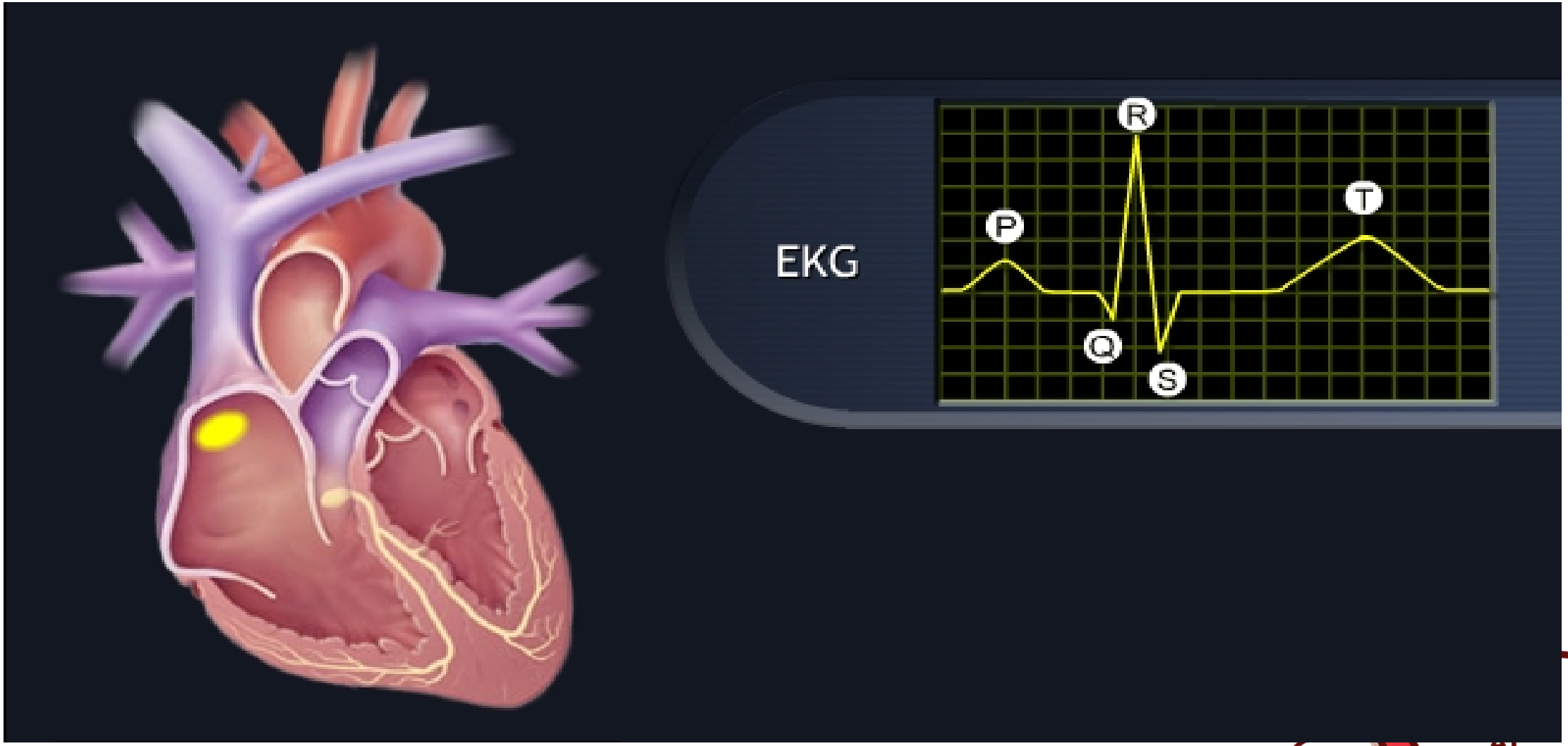

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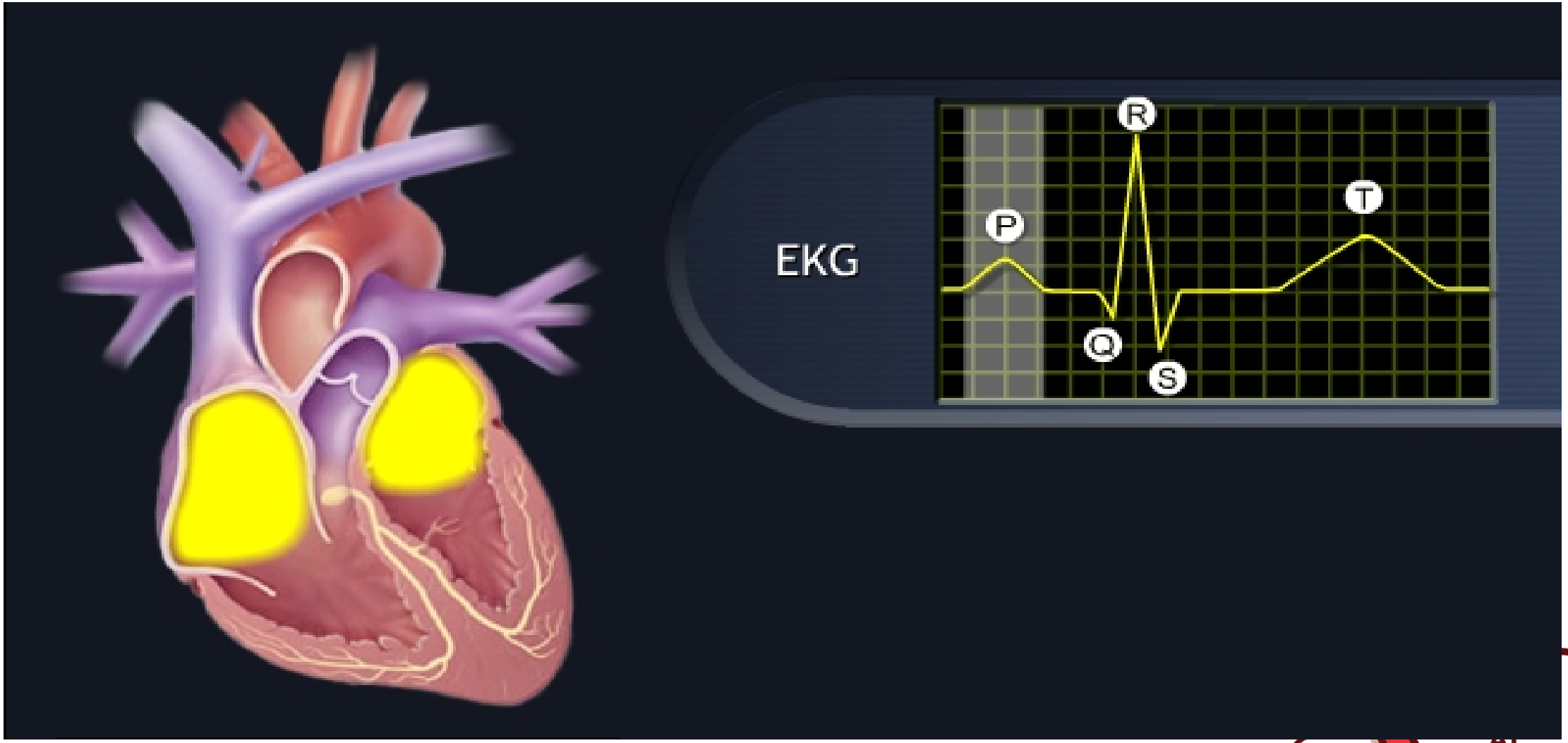

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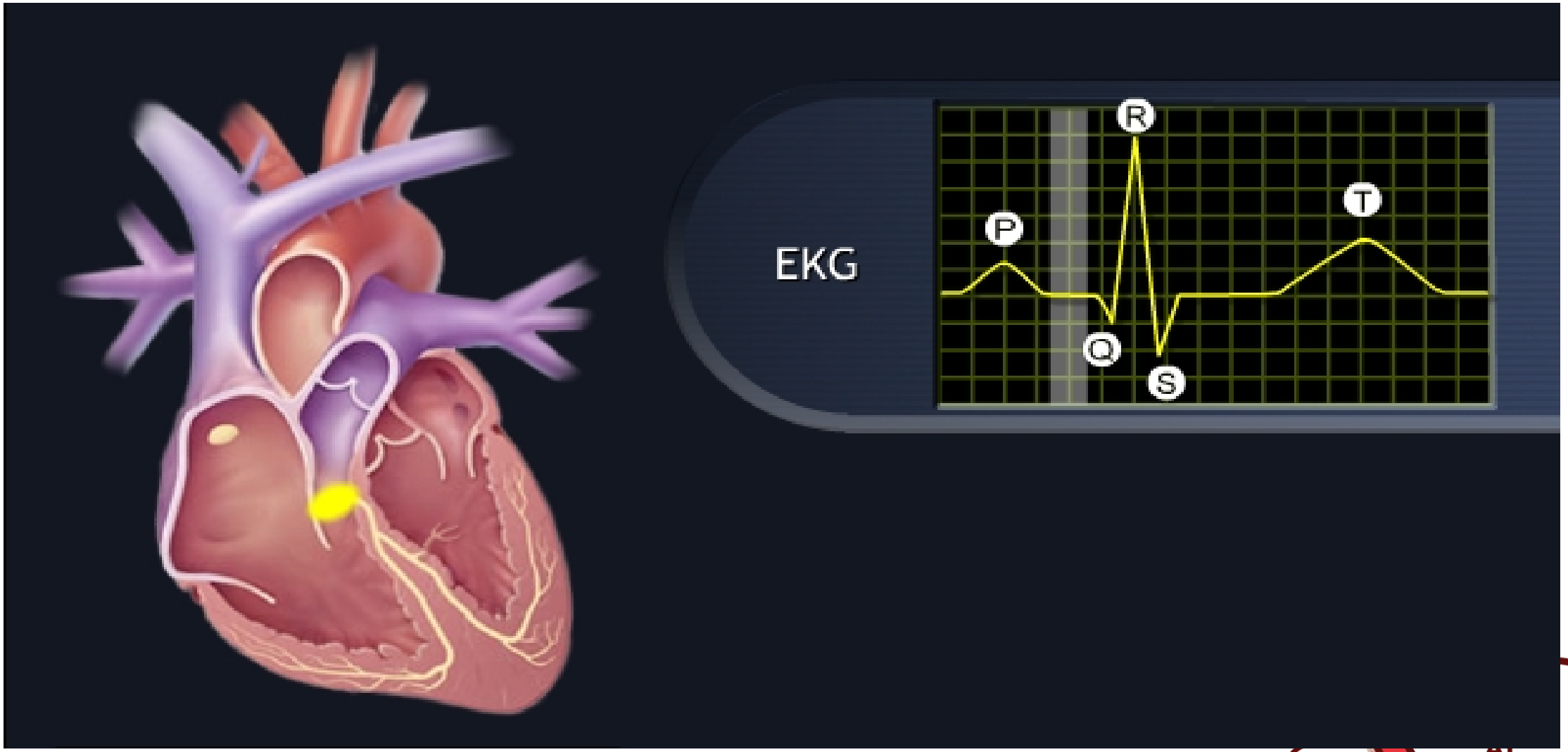

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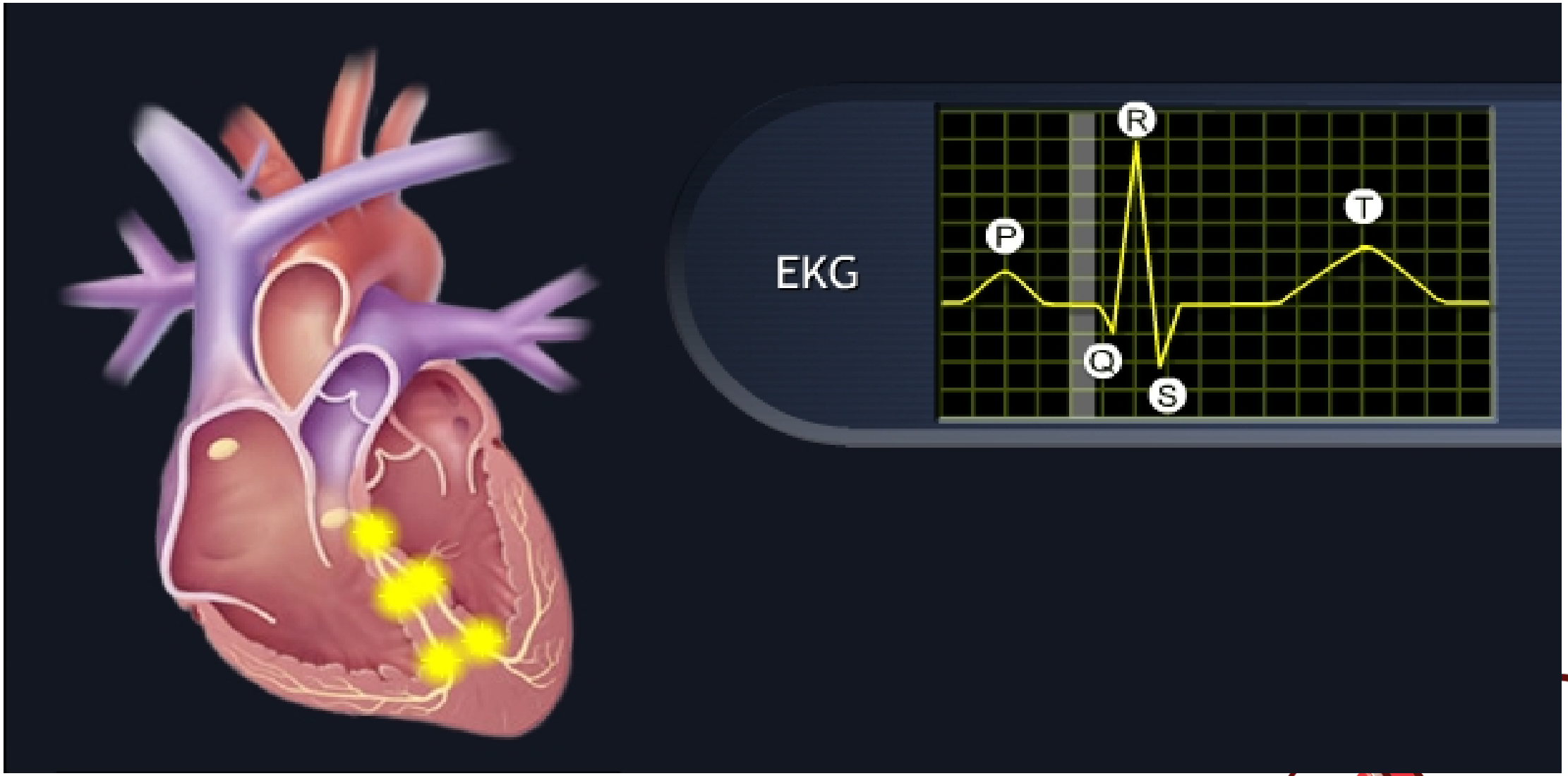

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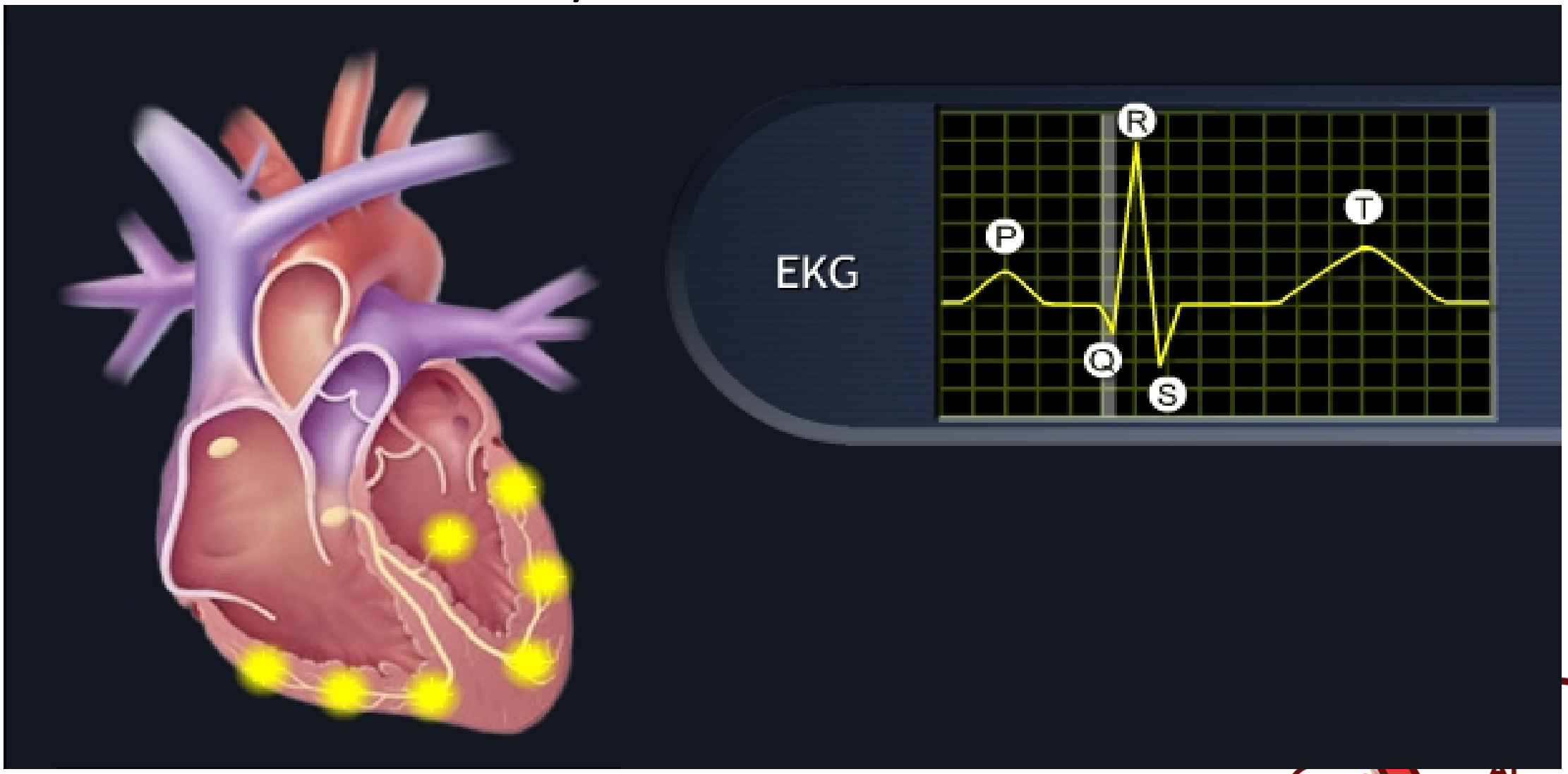
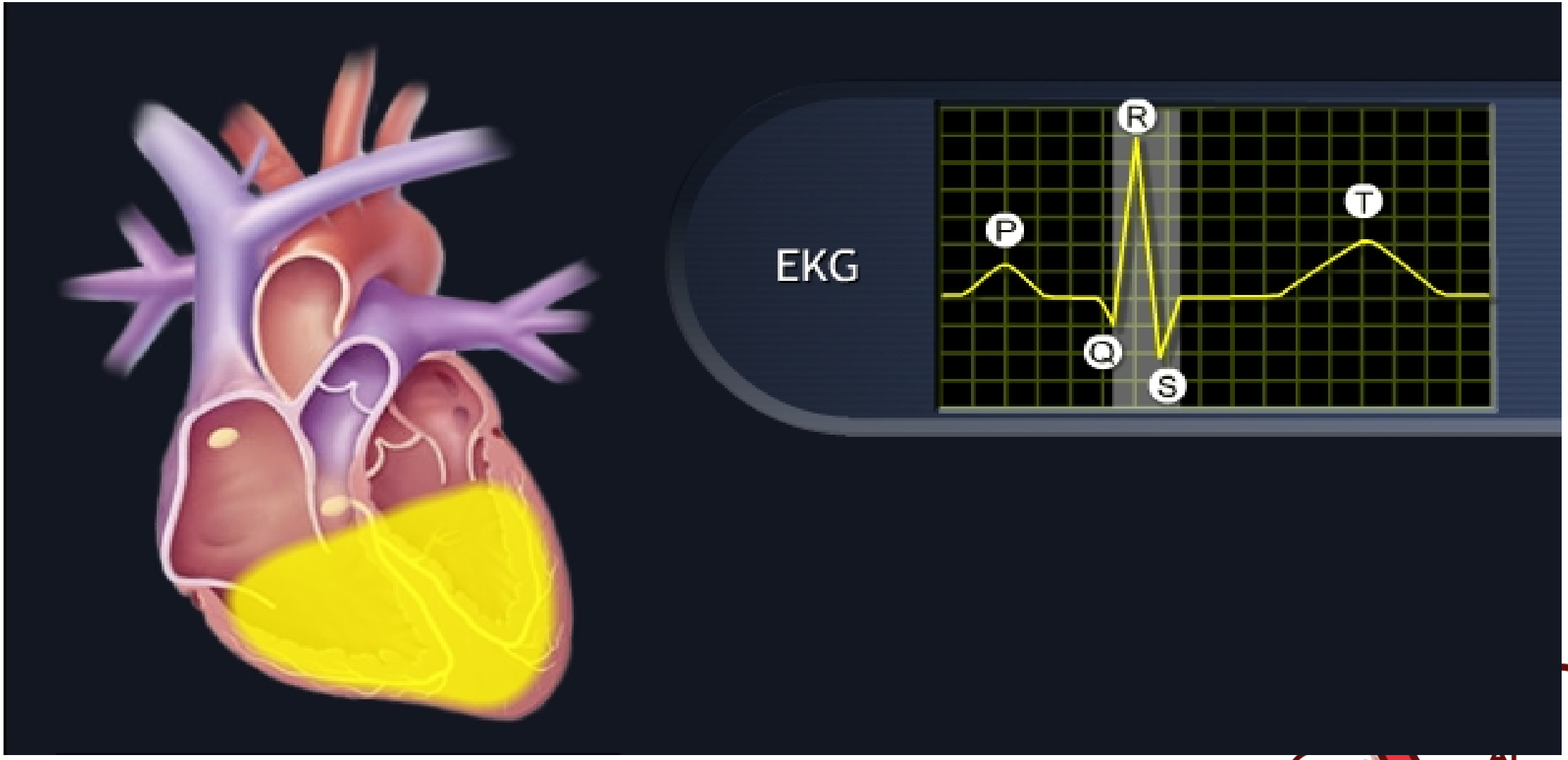
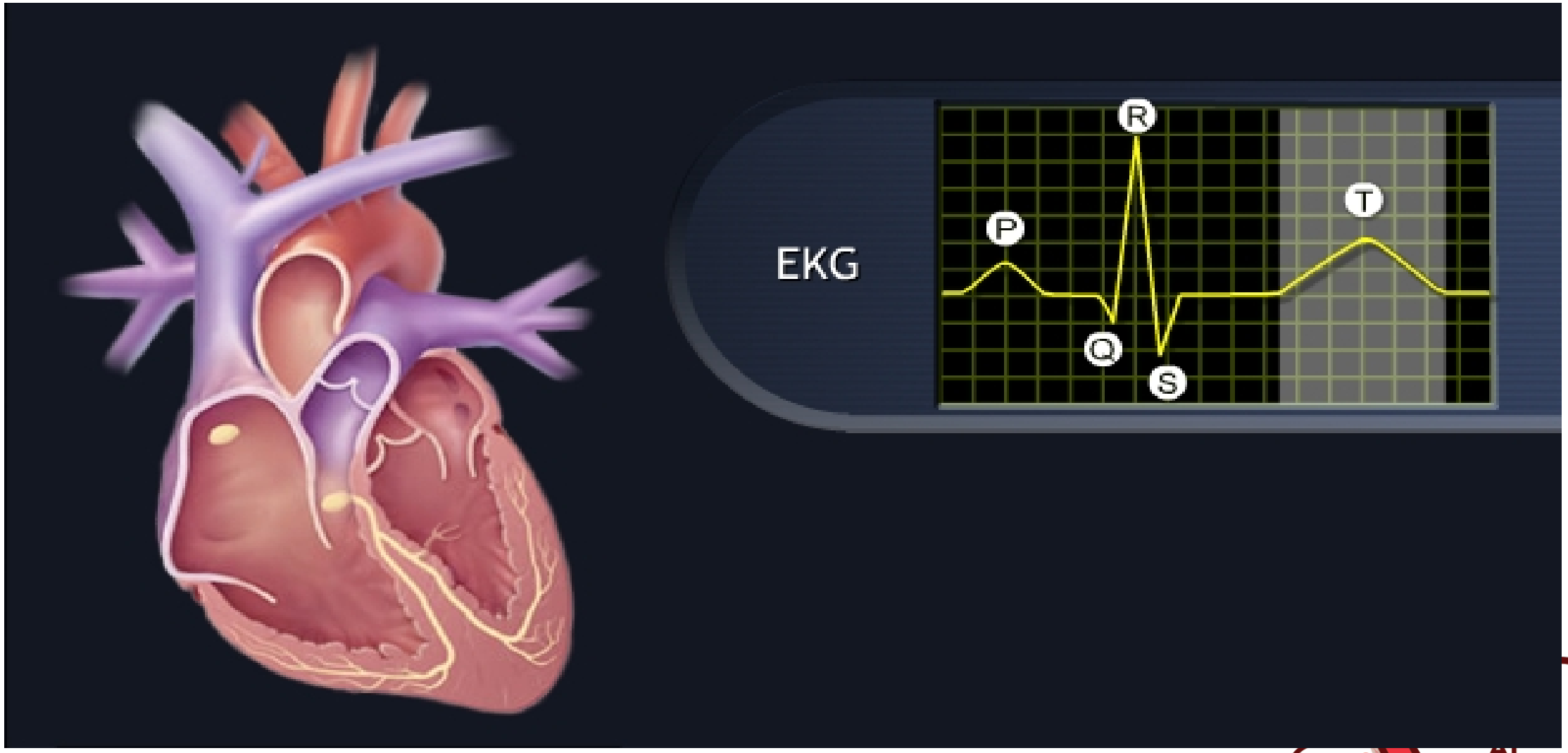


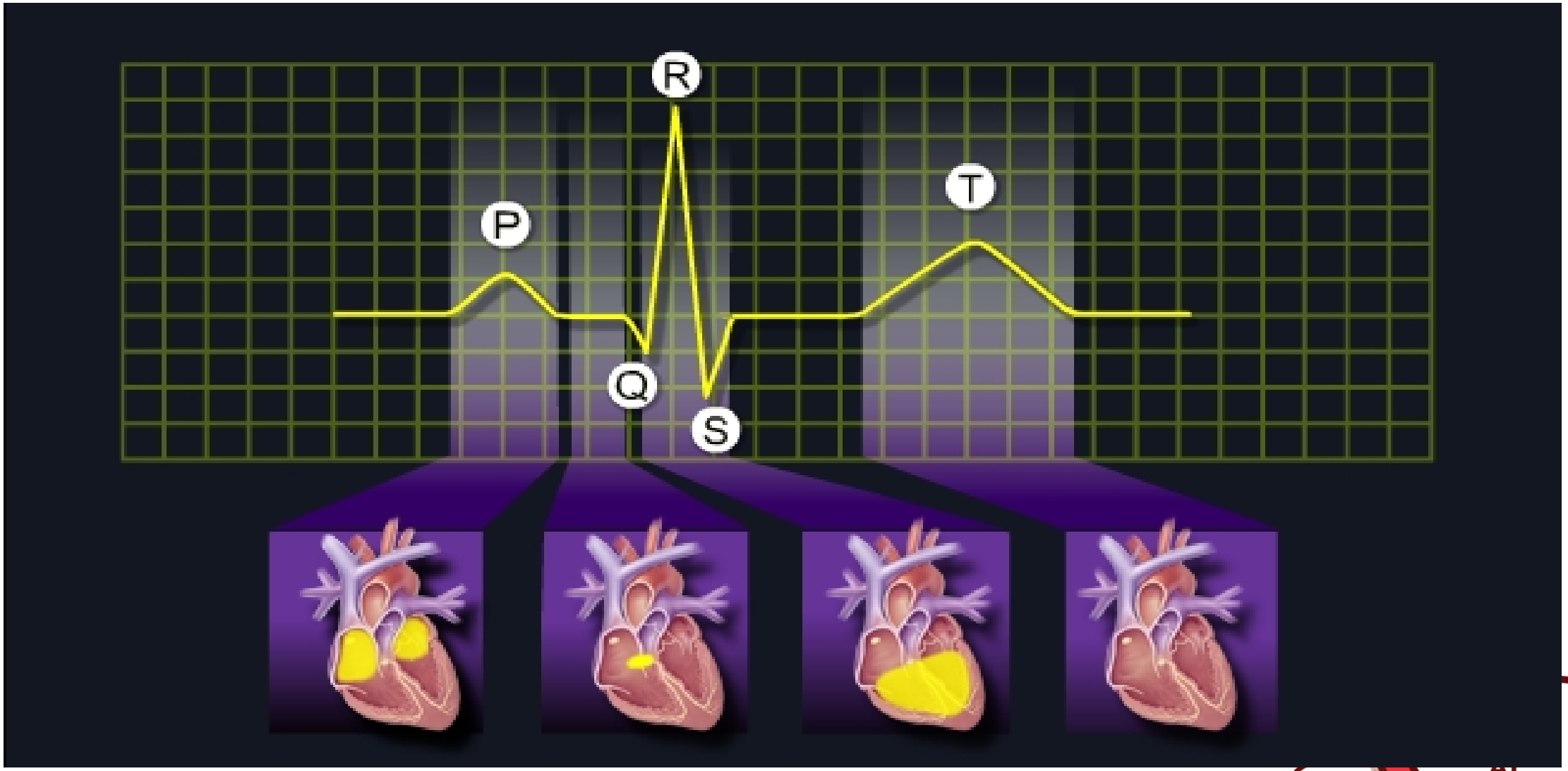
Normal Sinus Rhythm



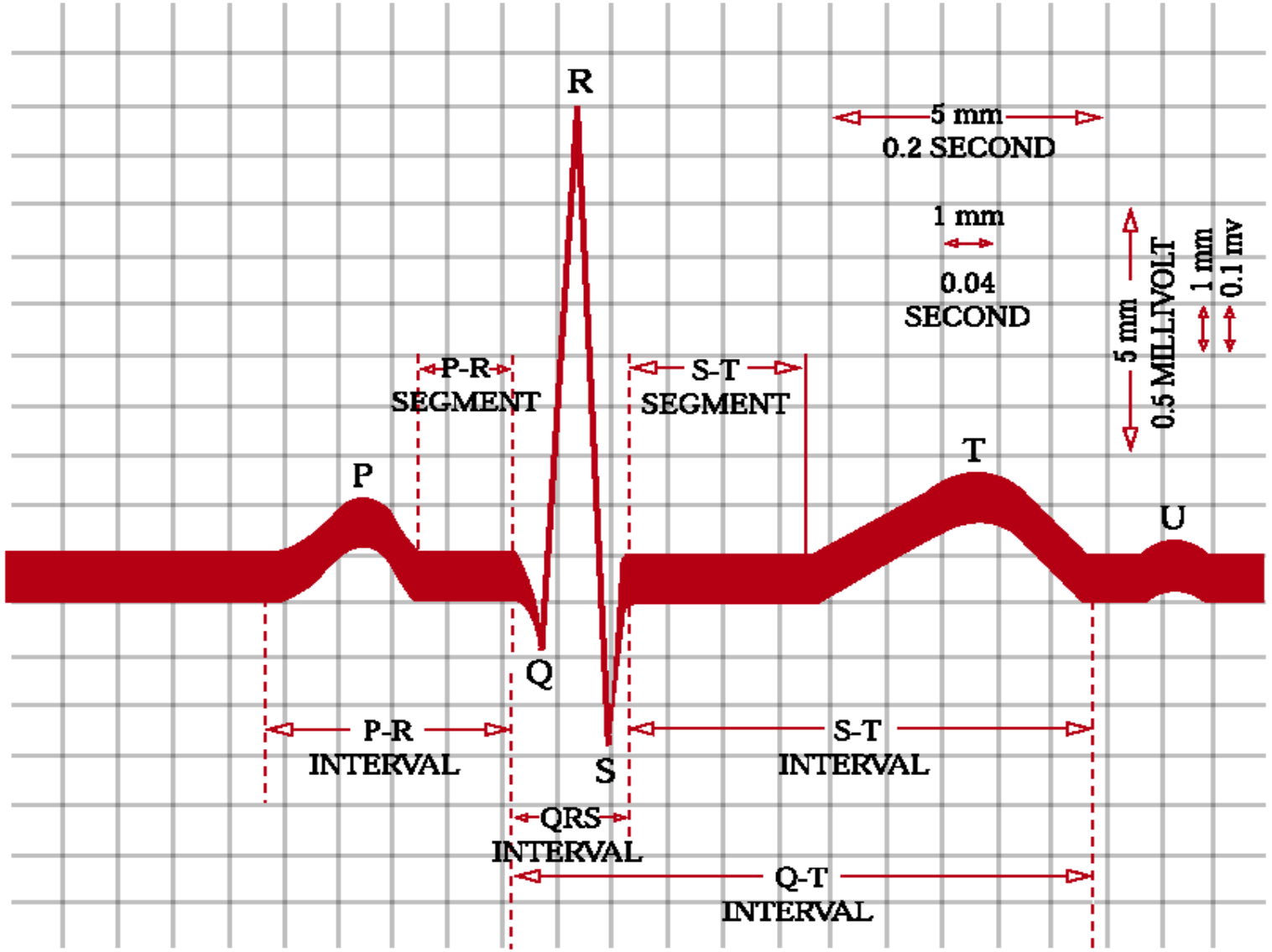
Normal Sinus Rhythm



Normal Sinus Rhythm

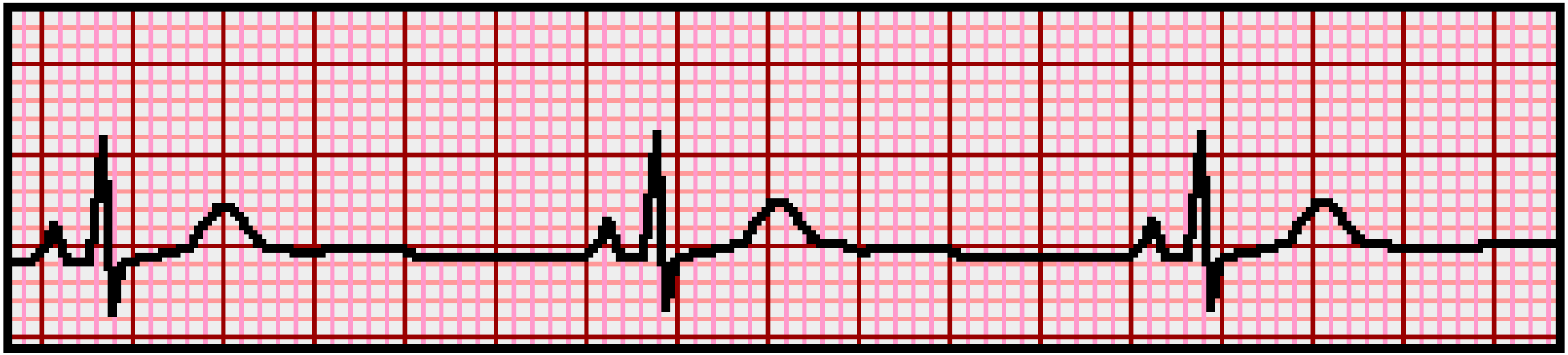


Normal features of the electrocardiogram



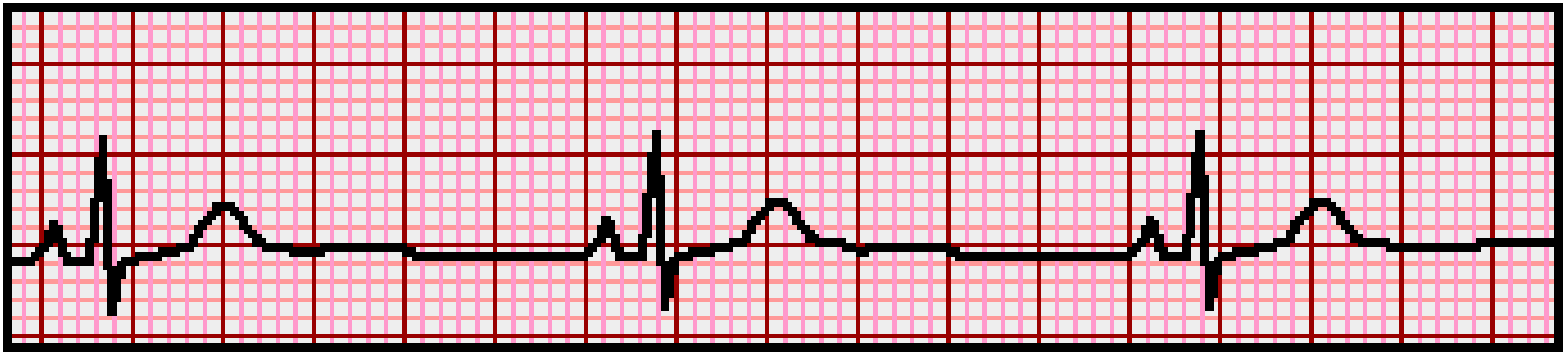
Recording Conventions, Waveform Nomenclature, and Normal Values for the Electrocardiogram.

What is the approximate heart rate ?



1. 40
2. 50
3. 60
4. 70

What is the approximate heart rate ?



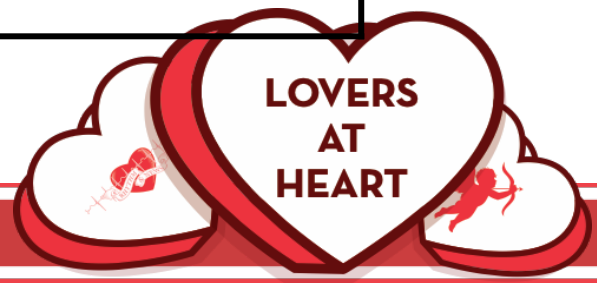
1. 40
2. 50
3. 60
4. 70

Calculation of Heart Rate

- Rule of 300
  - Divide 300 by the number of boxes between each QRS = rate

- Although fast, this method only works for regular rhythms.

Number of big boxes	Rate
1	300
2	150
3	100
4	75
5	60
6	50



Standardized Methods & Devices

- **ECG Graph Paper**
  - Vertical axis- voltage
    - 1 small box = 1 mm = 0.1 mV
  - Horizontal axis - time
    - 1 small box = 1 mm = 0.04 sec.
  - Every 5 lines (boxes) are bolded
  - Horizontal axis - 1 and 3 sec marks

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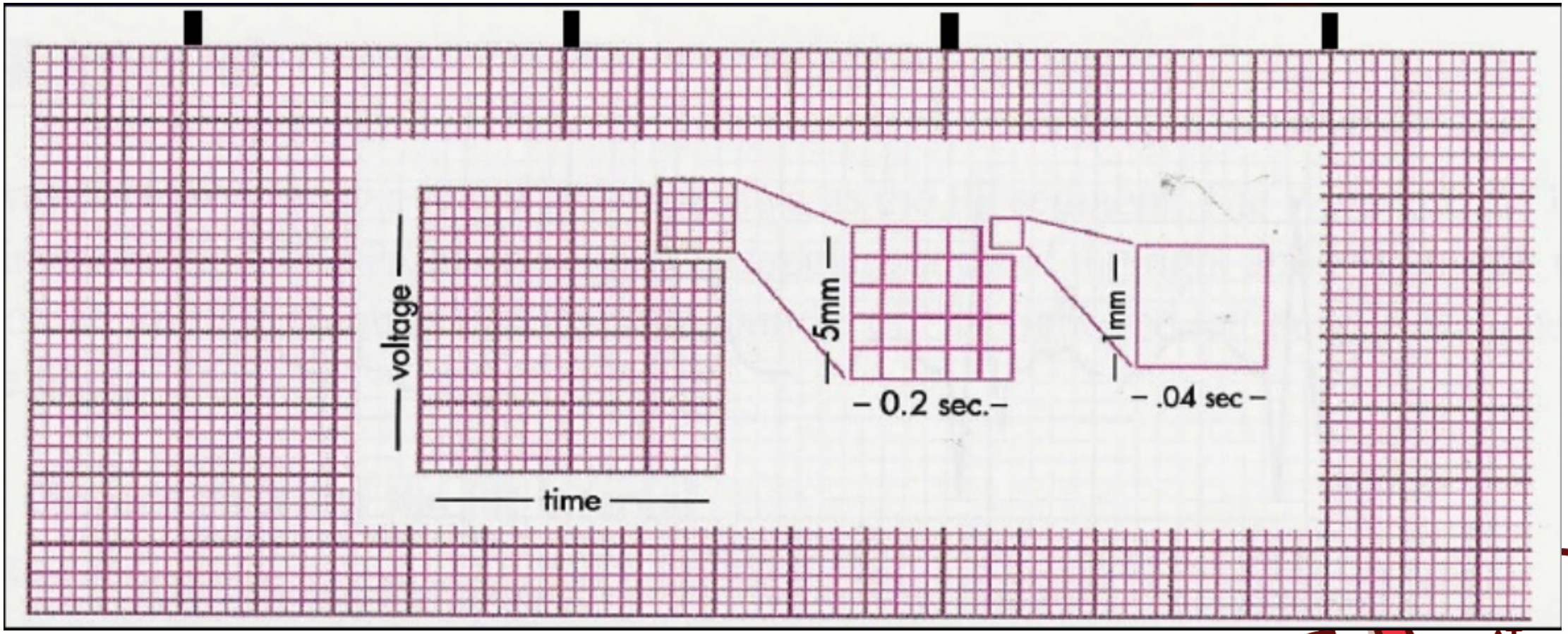
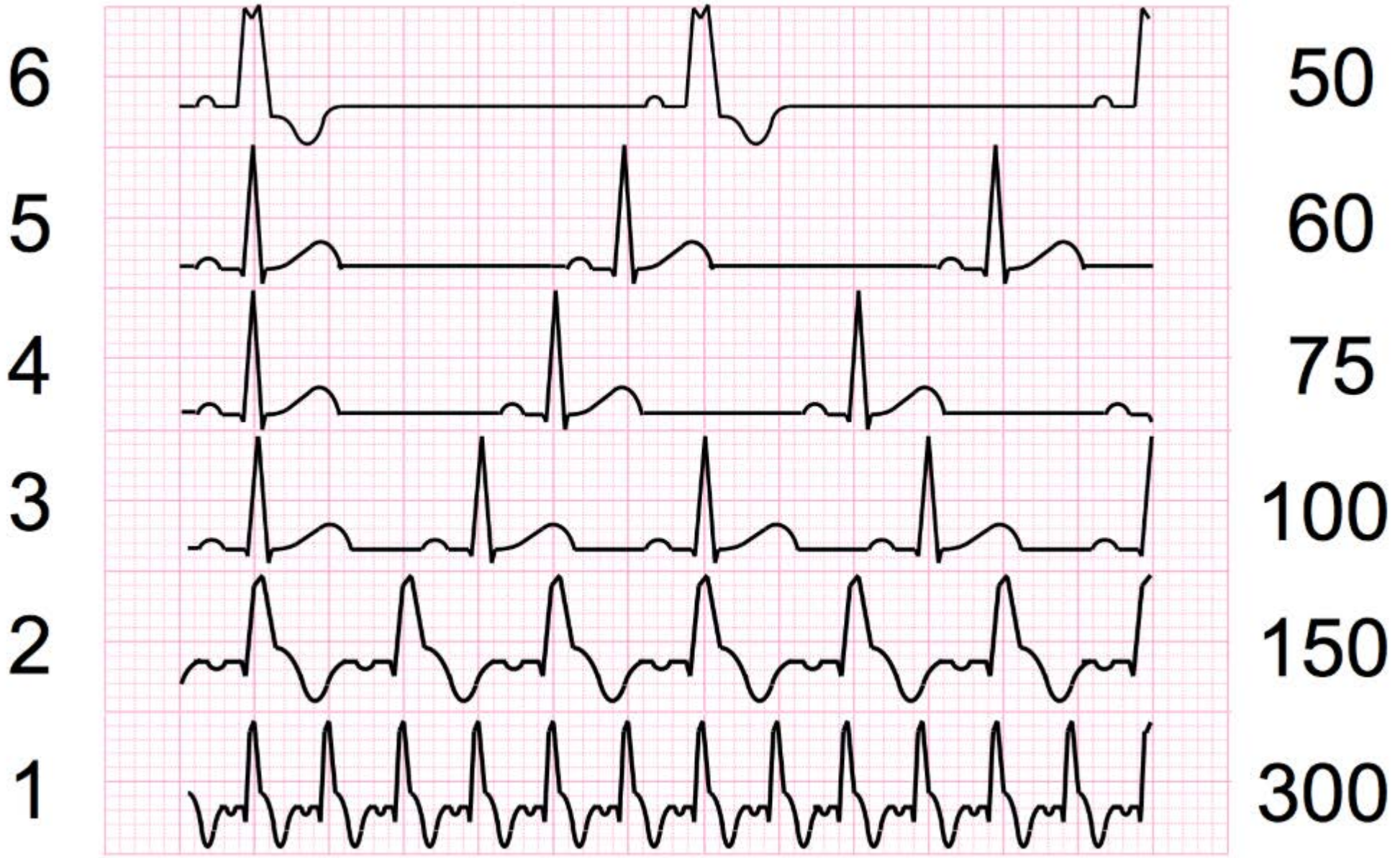
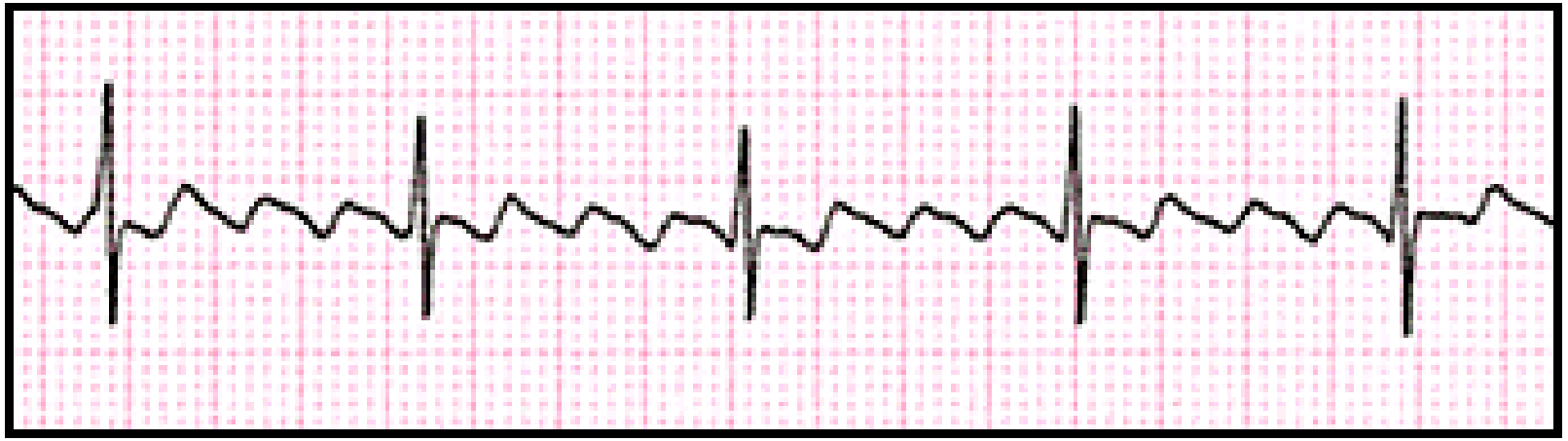

voltage
time
5mm
– 0.2 sec.–
1mm
– .04 sec –



LOVERS AT HEART

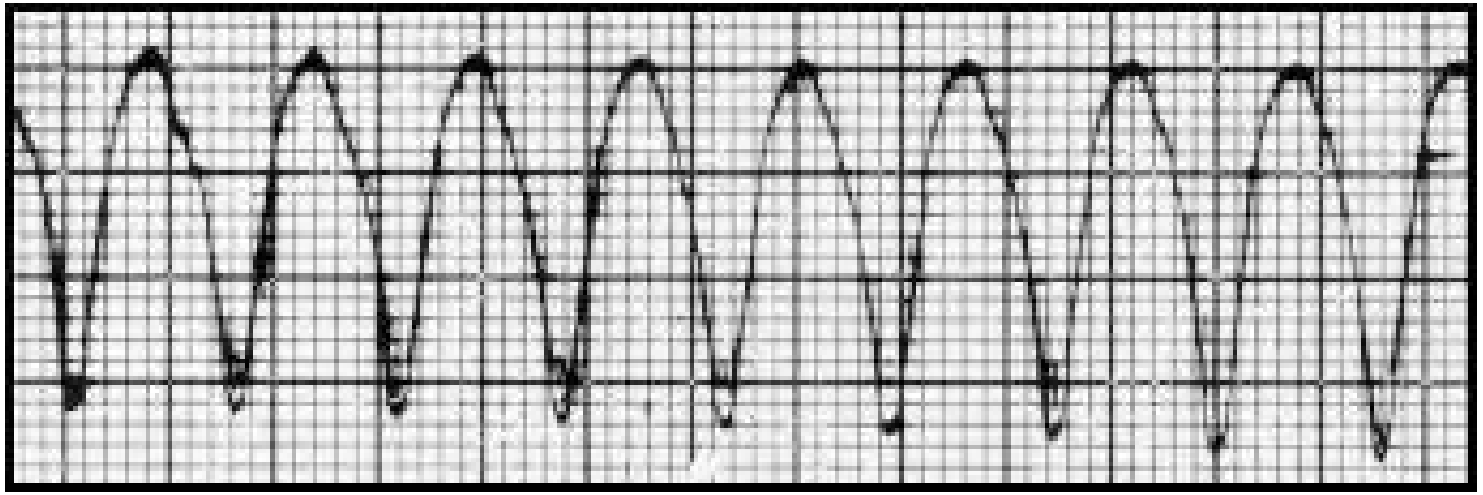
What is the heart rate?



www.uptodate.com

(300 / ~ 4) = ~ 75 bpm

What is the heart rate?



(300 / 1.5) = 200 bpm

Outline

- ECG Basics

- Common ECG Missteps
  - Old infarct
  - Heart blocks
  - Wide complex tachycardia
  - ST elevation on ECG

- Common Telemetry Missteps
  - Artifact
  - Inaccurate HR

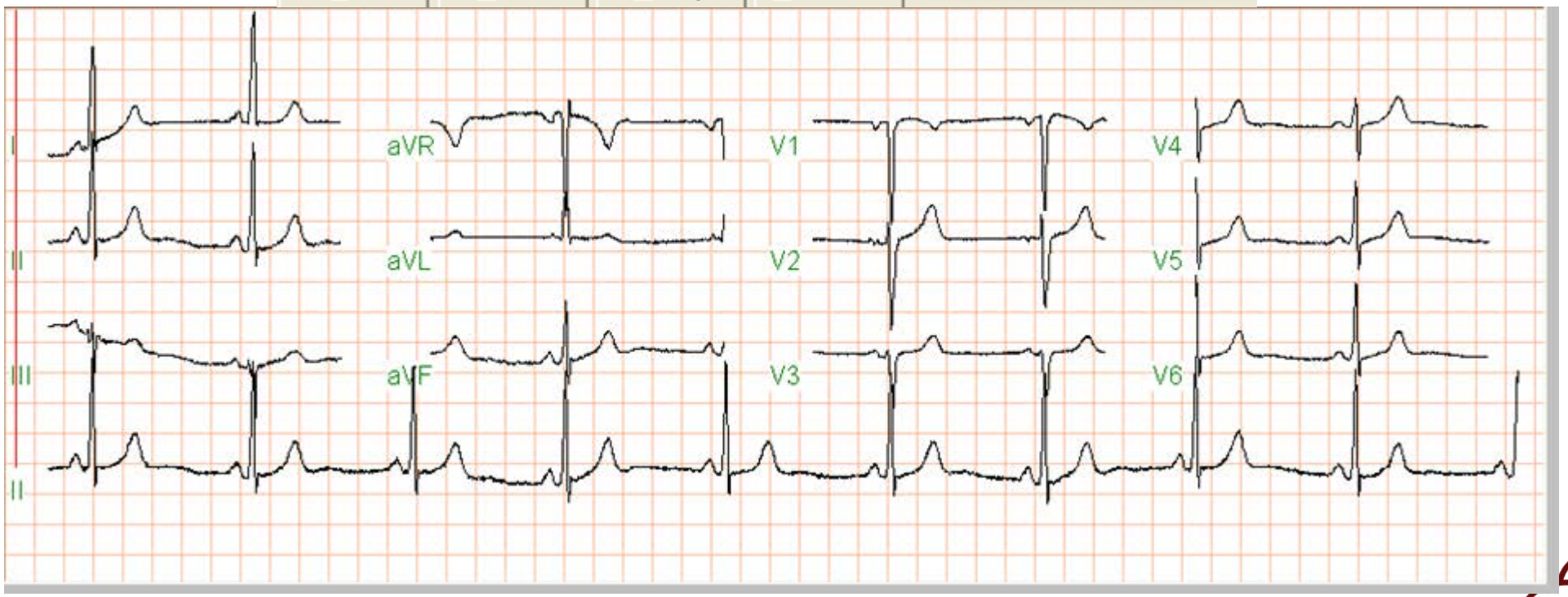
48 year old for Pre-Op ECG

Sinus Bradycardia
-Old anterior infarct

ABNORMAL

Rate:	55	BPM
PR:	124	msec
QT:	418	msec
QTc:	411	msec
QRSD:	84	msec
P Axis:	49	
QRS Axis:	19	
T Axis:	43	

Add | Delete | Modify | Clear/Add



In order to “clear” patient for surgery

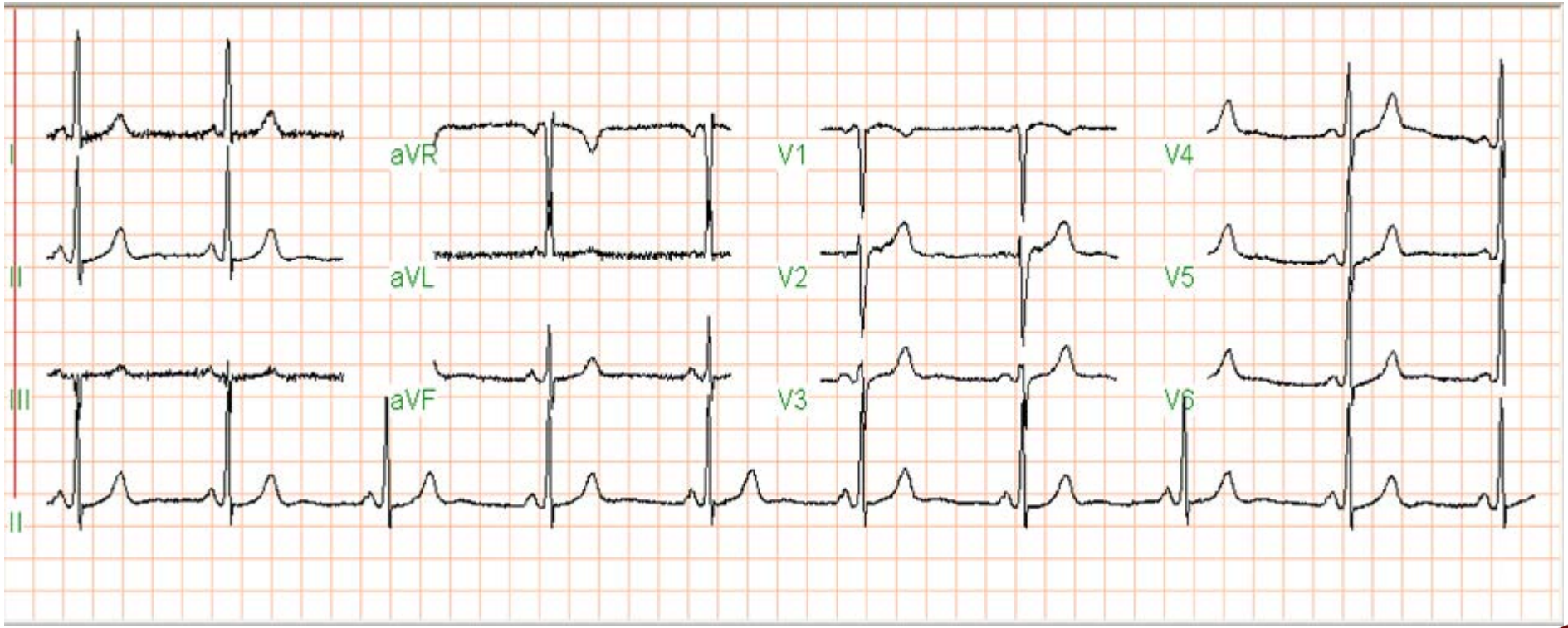
1. Repeat ECG
2. Exercise treadmill test (without imaging)
3. Stress echocardiography
4. Cardiac catheterization

In order to “clear” patient for surgery

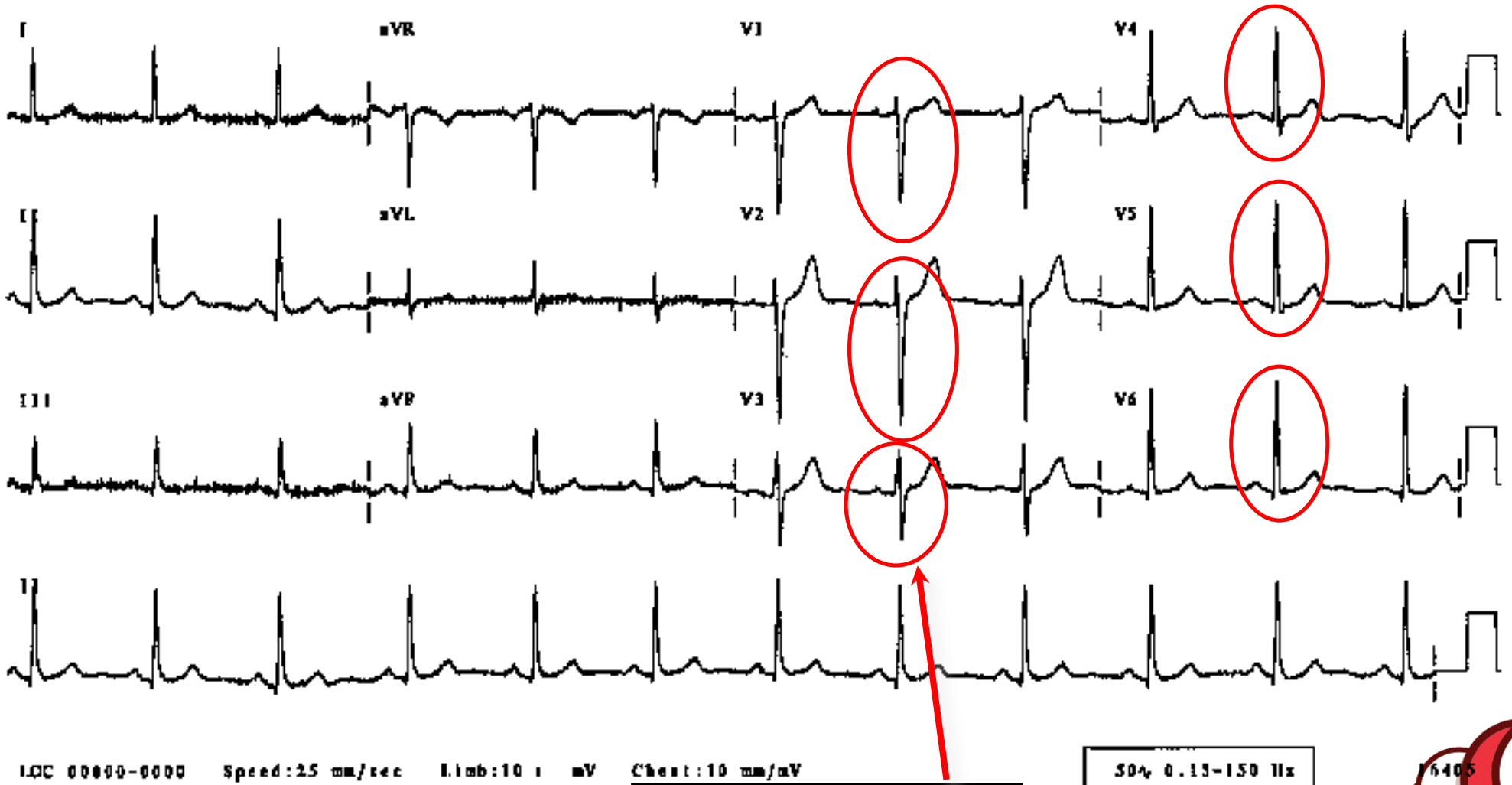
1. Repeat ECG
2. Exercise treadmill test (without imaging)
3. Stress echocardiography
4. Cardiac catheterization

With Proper Placement

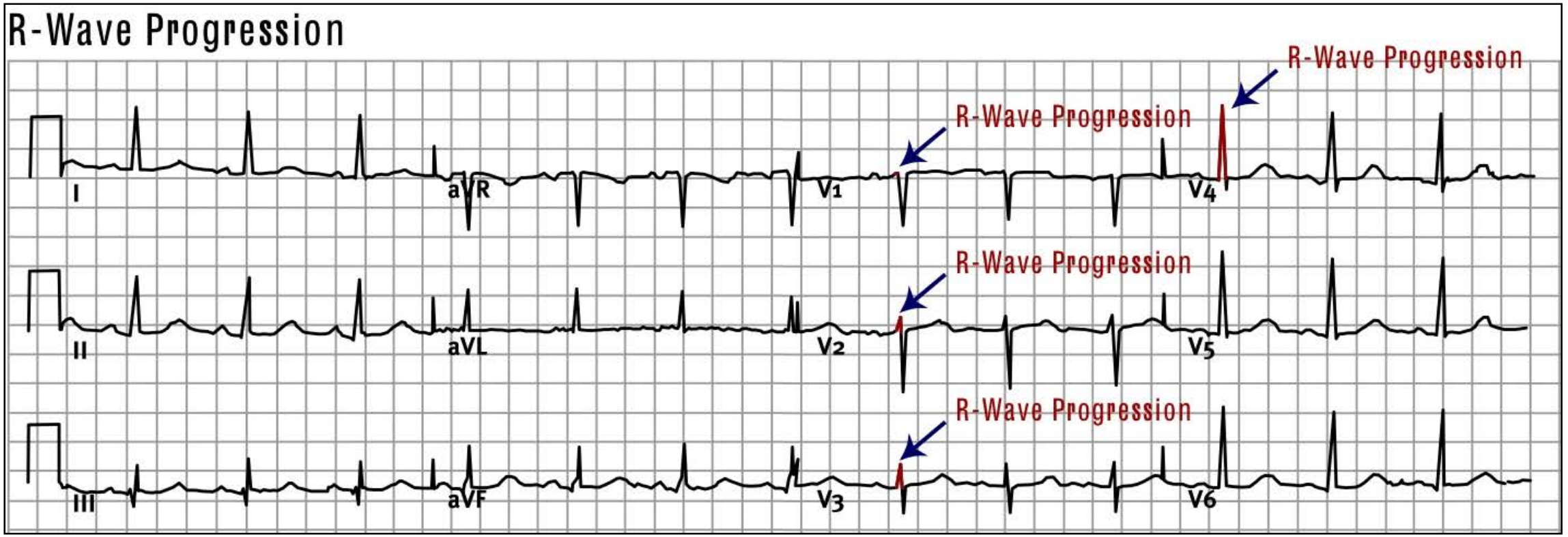
Sinus Bradycardia
WITHIN NORMAL LIMITS



Normal R Wave Progression

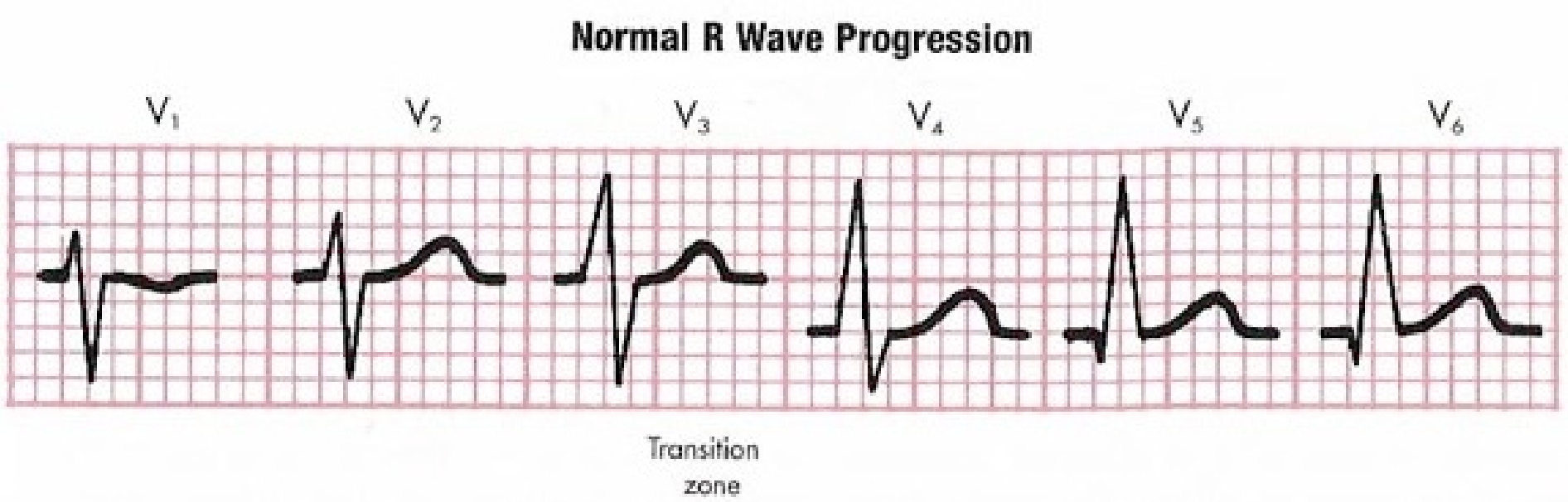


R Wave Progression

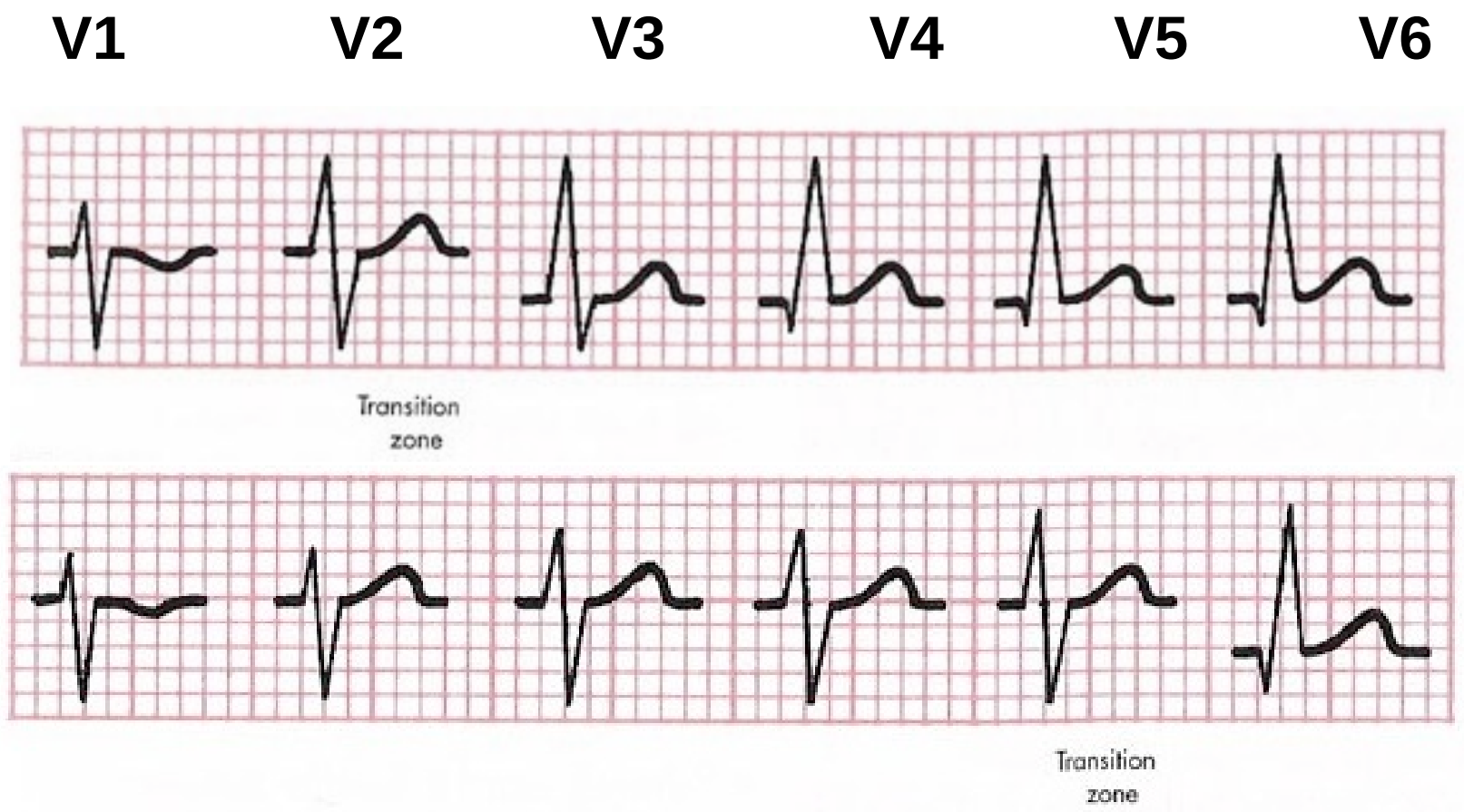


Transition Zone?

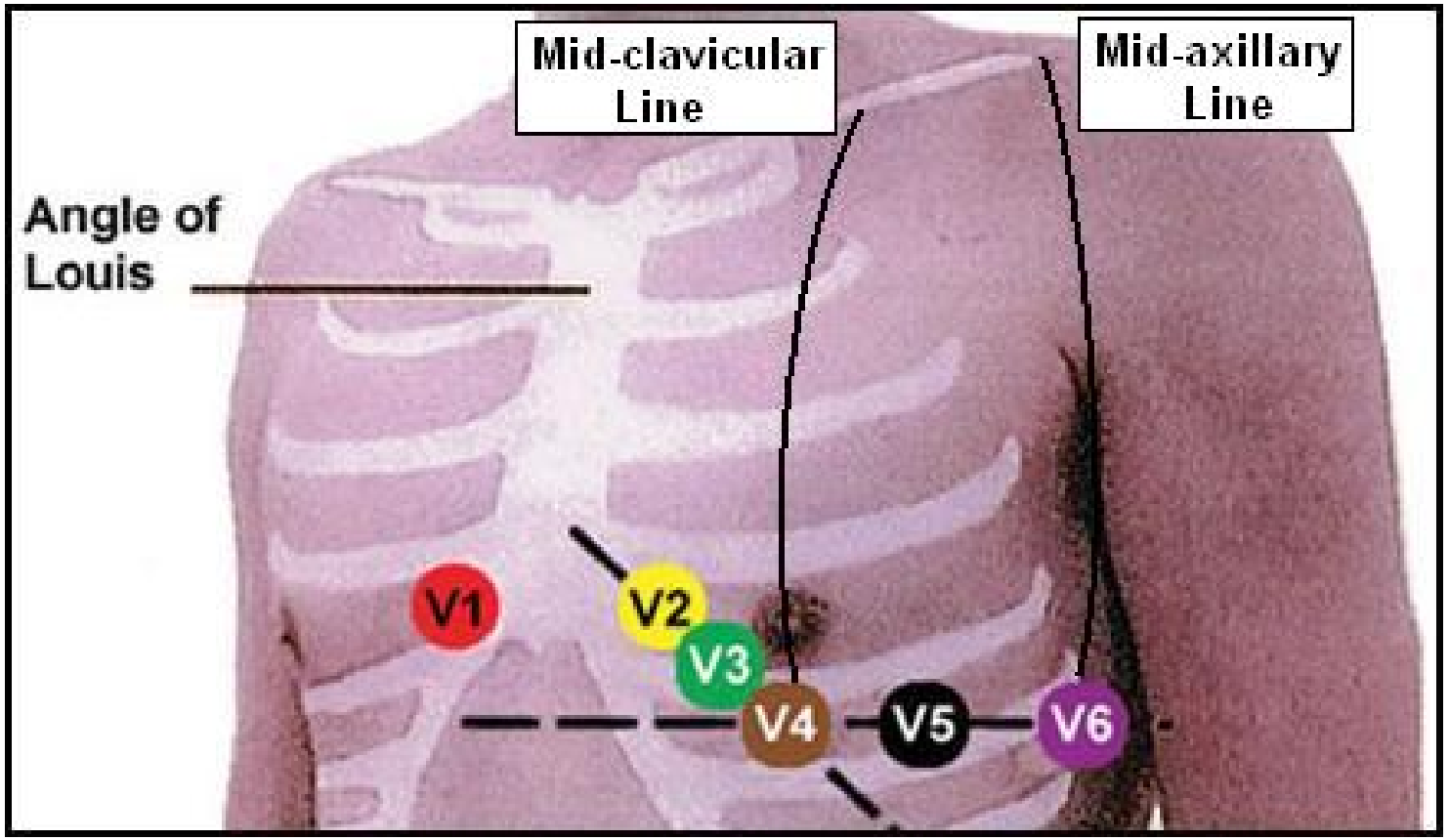
Transition Zone



Early & Delayed Transition

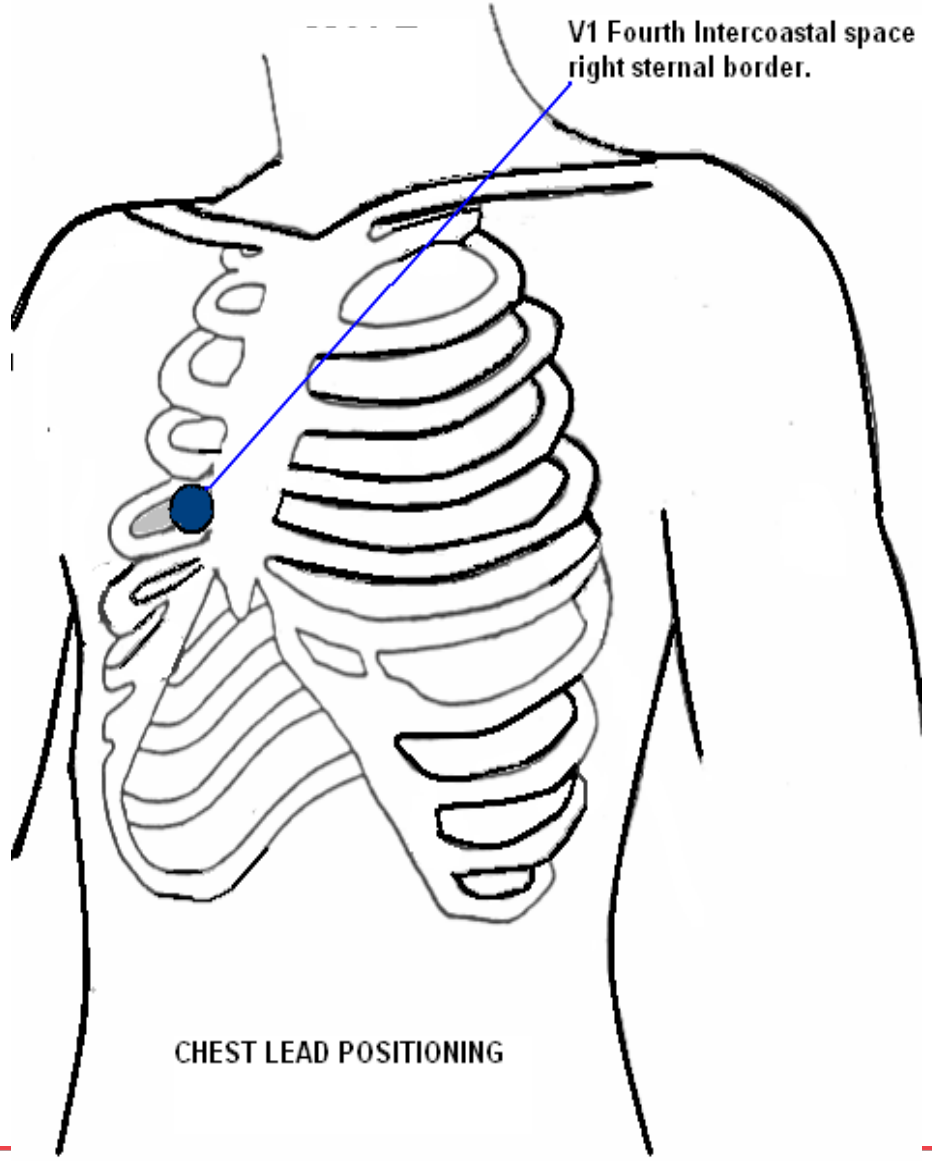


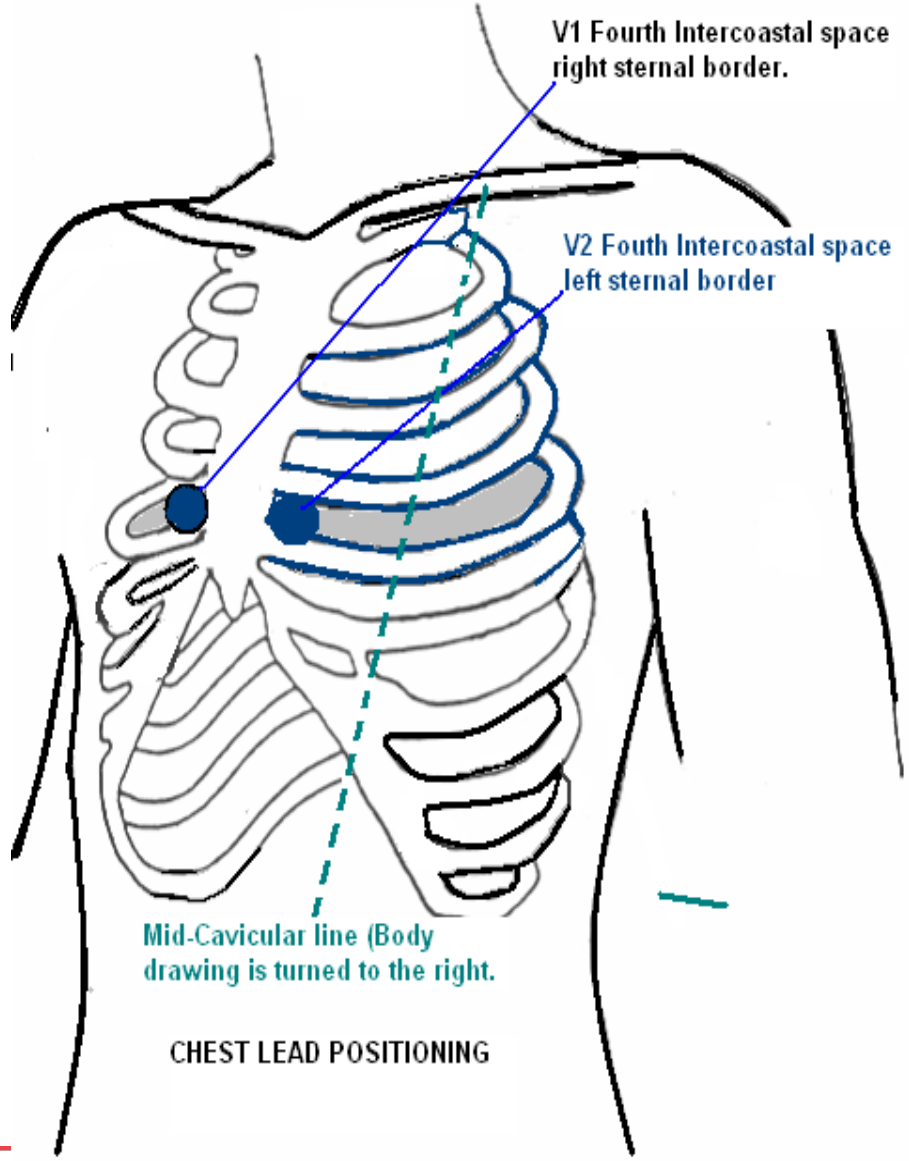
Precordial Leads



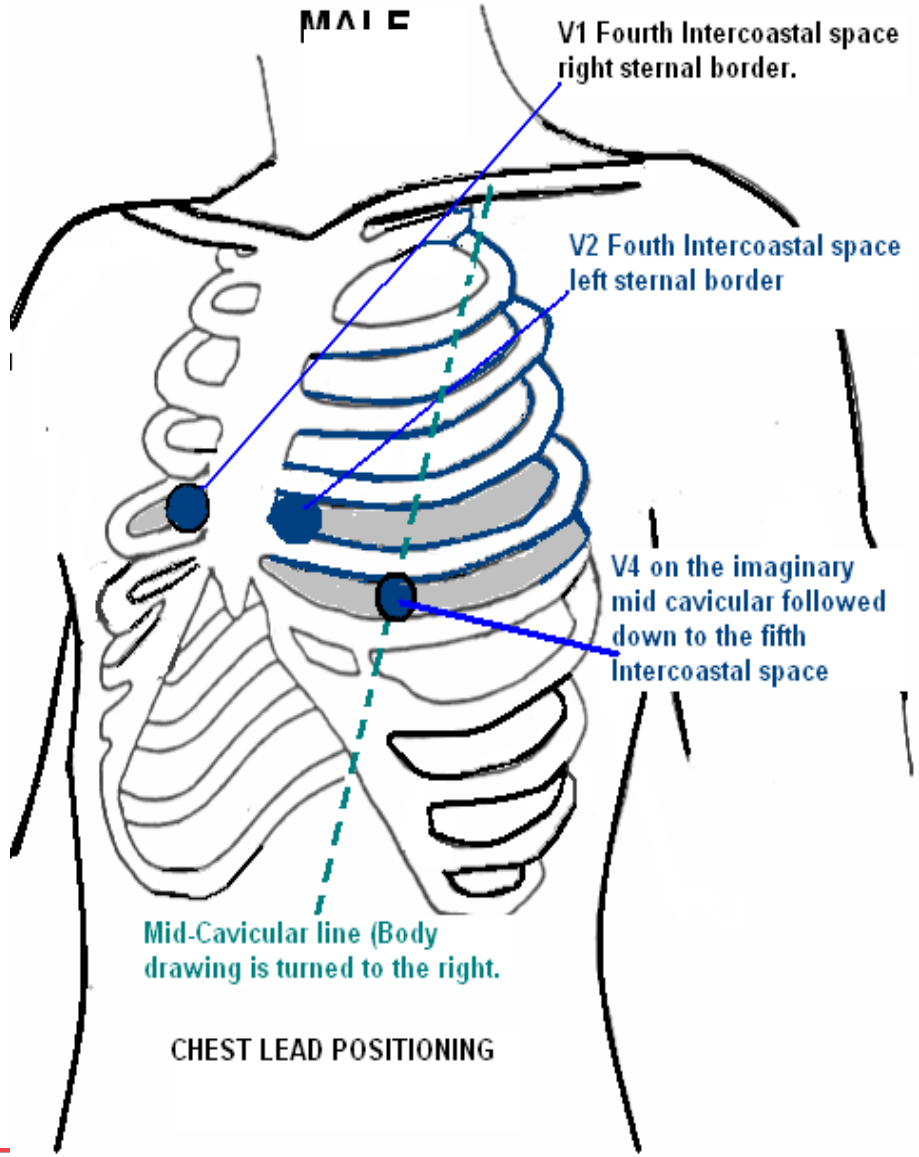
Adapted from: www.numed.co.uk/electrodepl.html

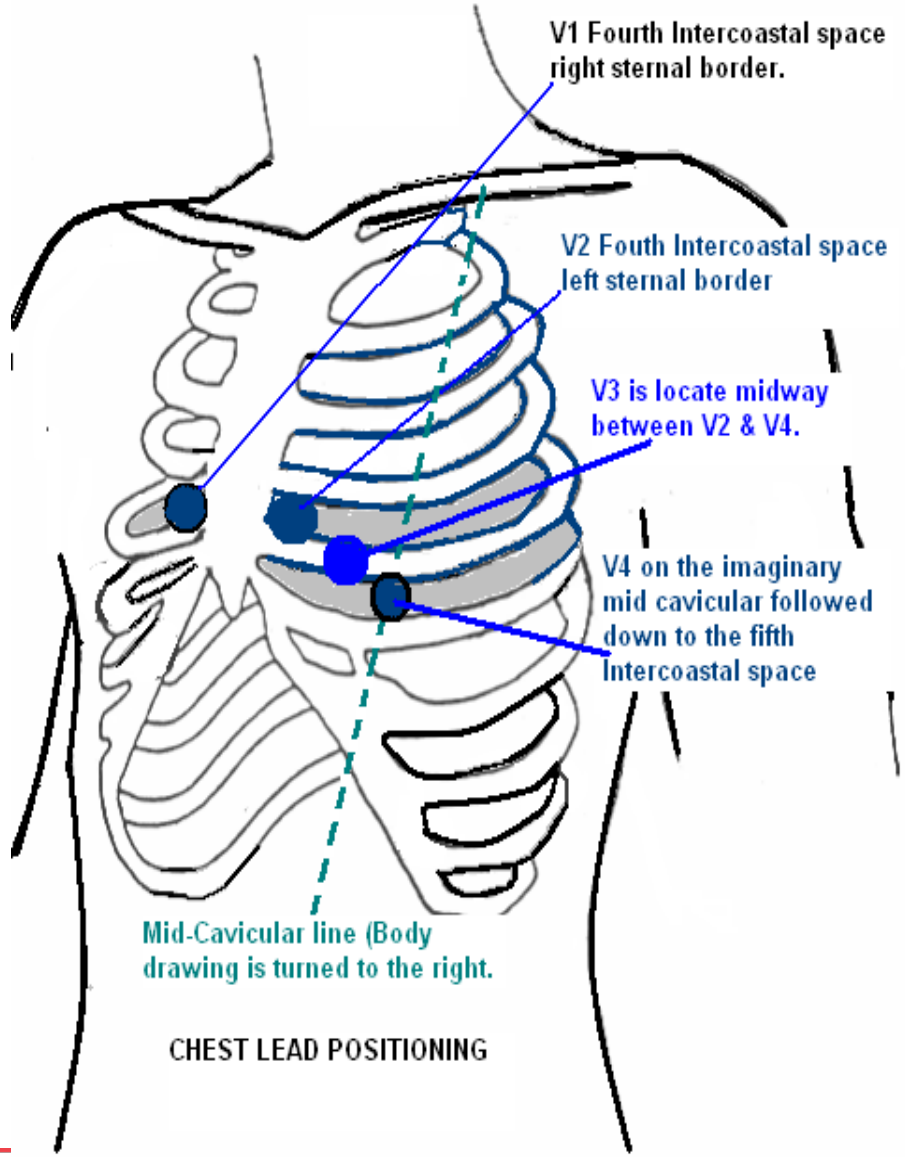
Chest Lead Placement





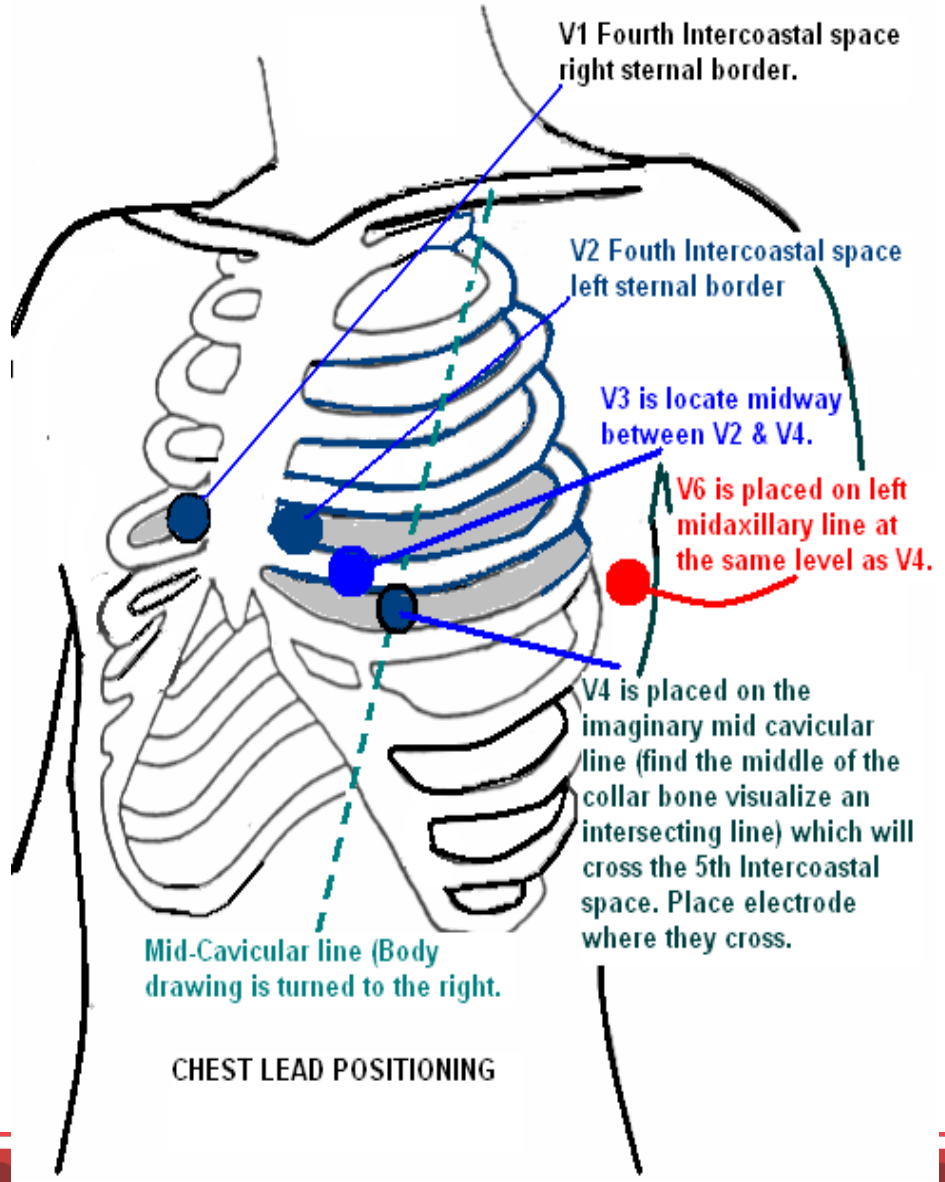
Chest Lead Placement

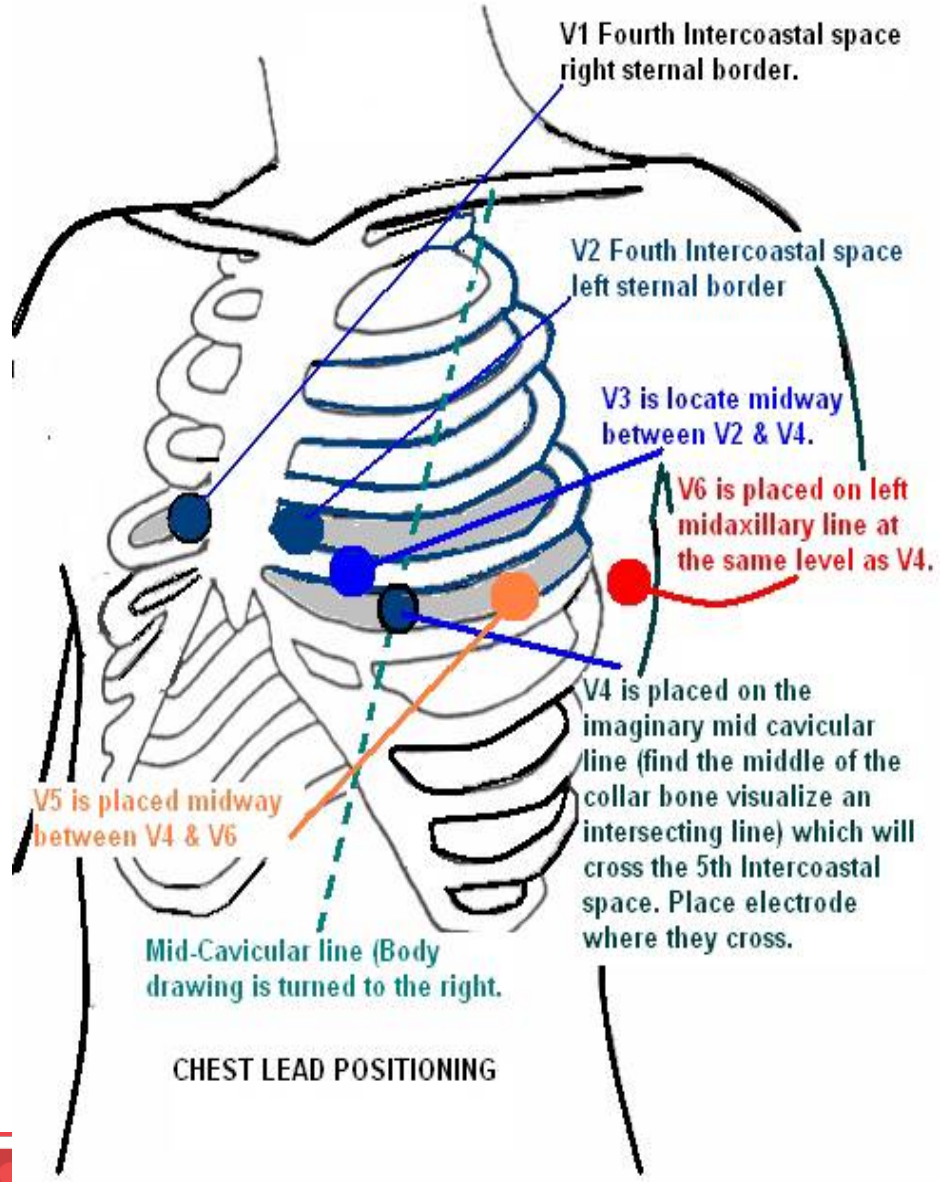




LOVERS AT HEART

Chest Lead Placement





Precordial leads

The location of these leads is as follows:

V_1: on the fourth intercostal space at the right sternal margin

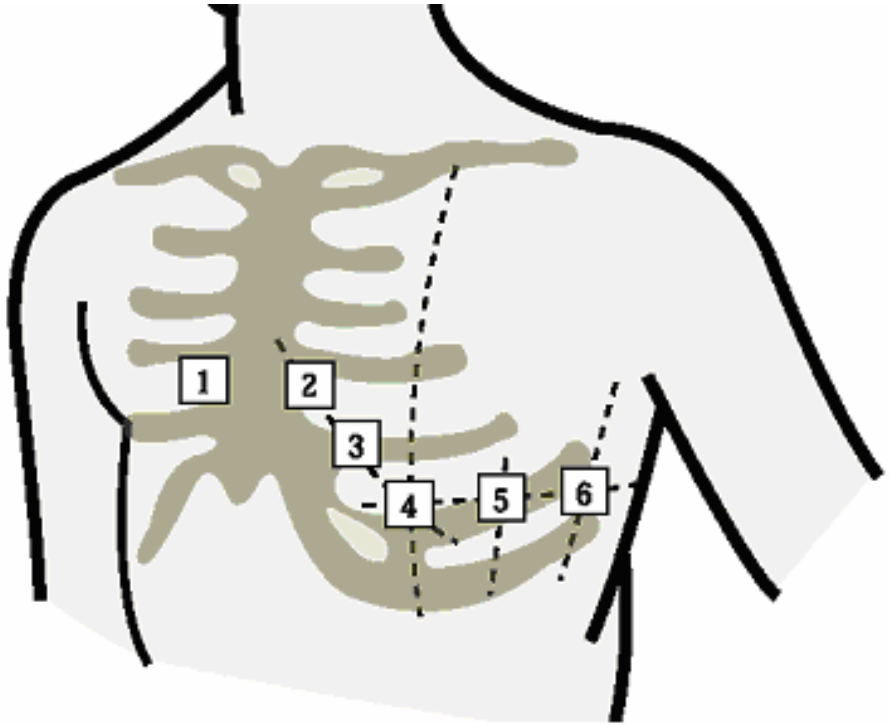
V_2: on the fourth intercostal space at the left sternal margin

V_3: midway between leads V2 and V4

V_4: on the fifth intercostal space at the midclavicular line

V_5: on the anterior axillary line at the horizontal level of lead V4

V_6: on the midaxillary line at the horizontal level of lead V4



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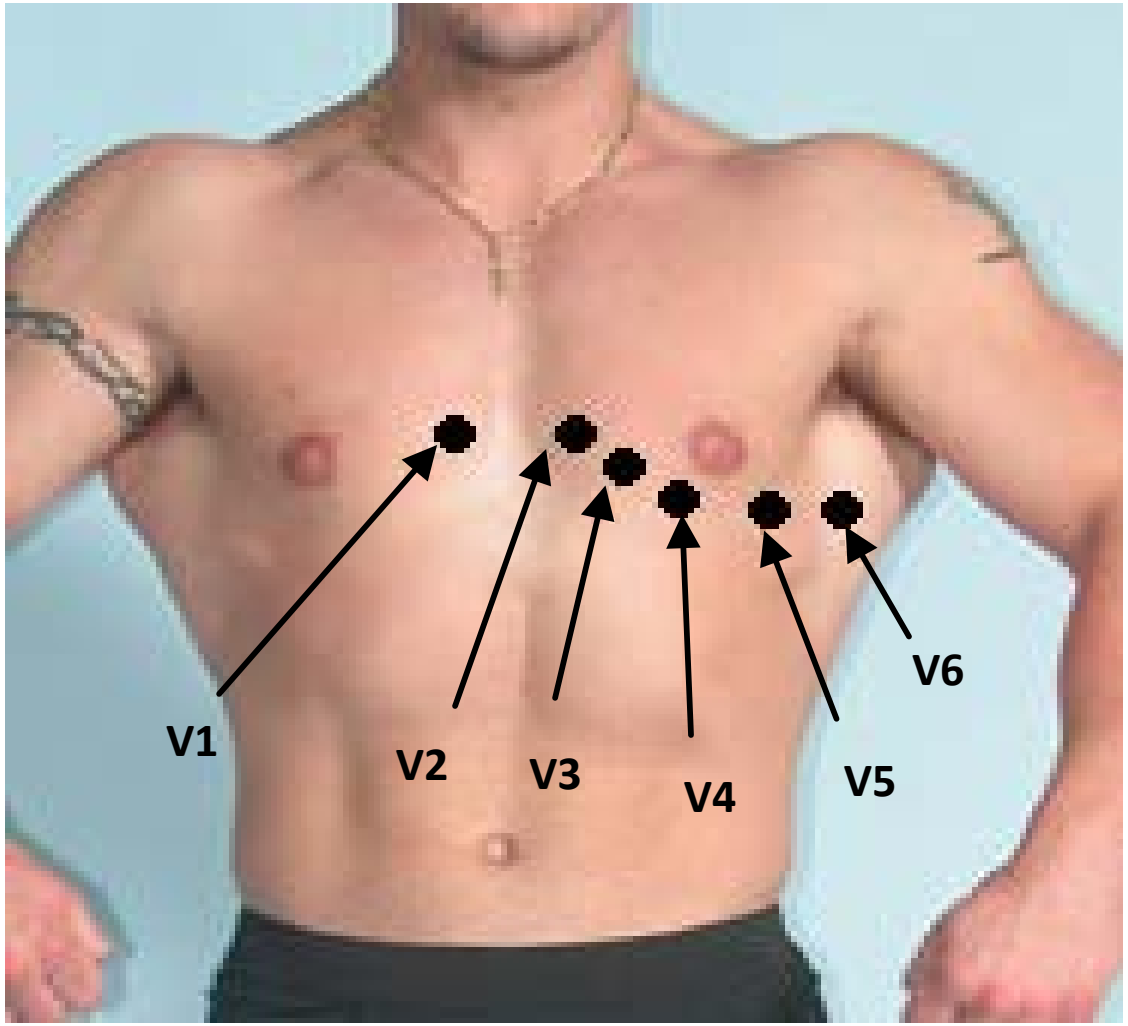

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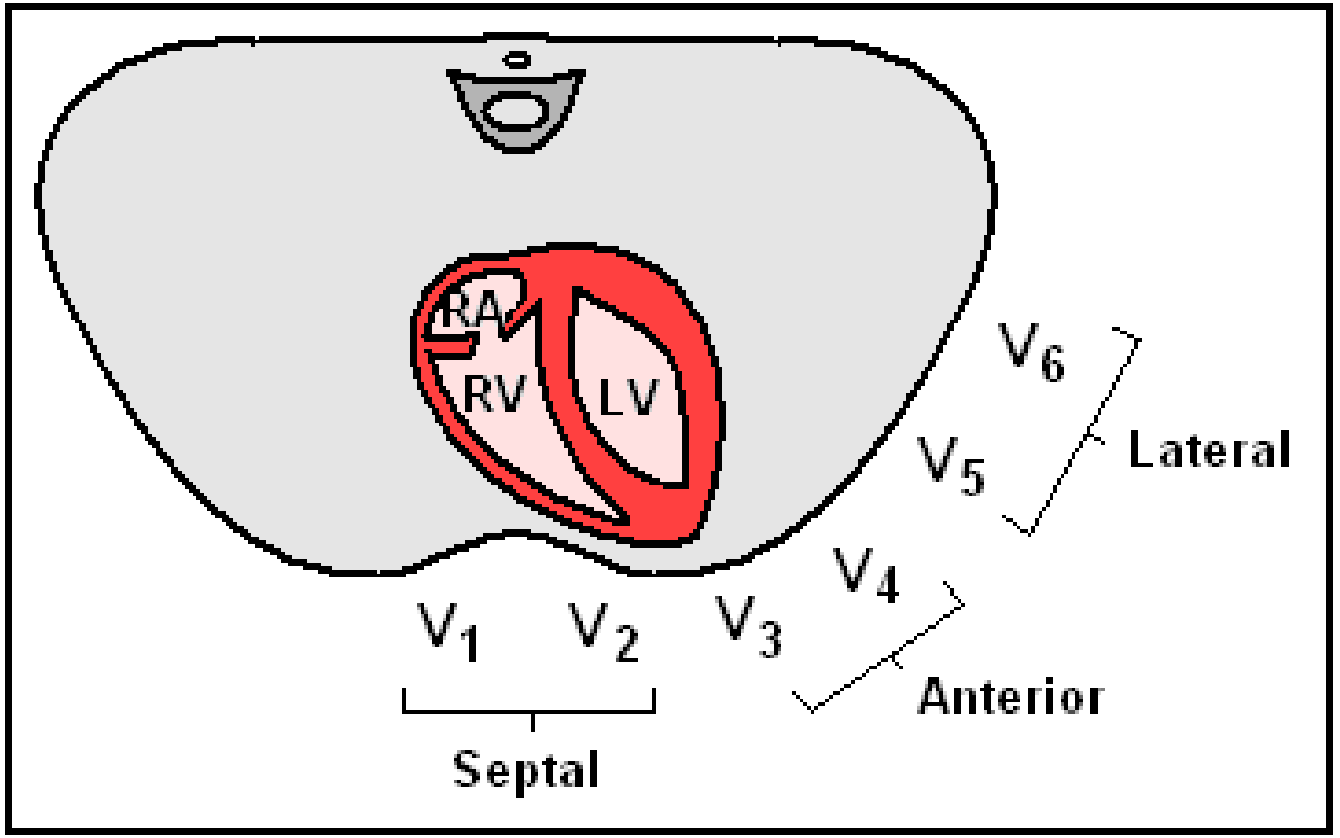
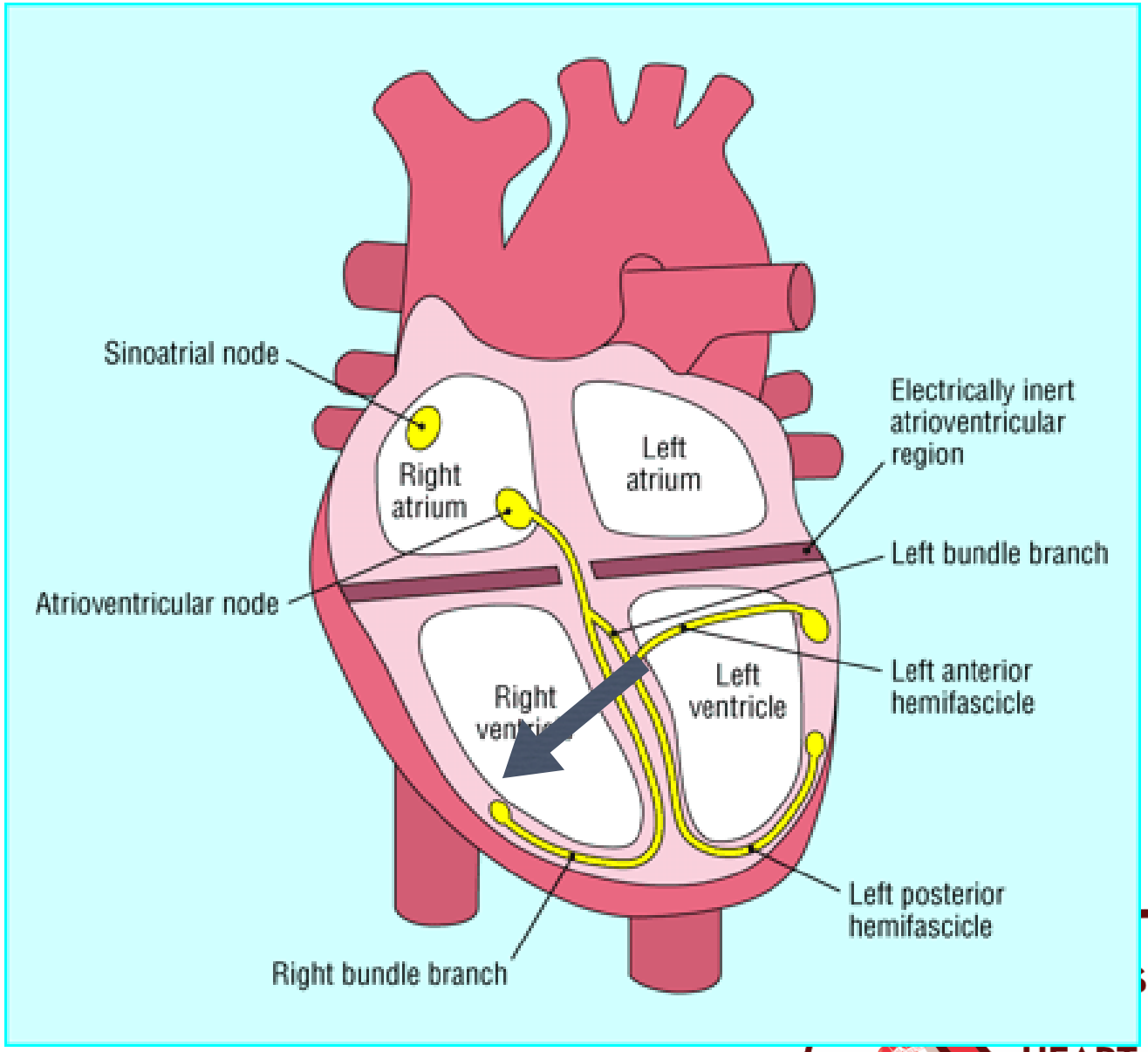


Normal QRS

- Two phases
  - Brief phase; depolarization of ventricular *septum*
  - Longer phase; depolarization of both *ventricles* but the left is larger

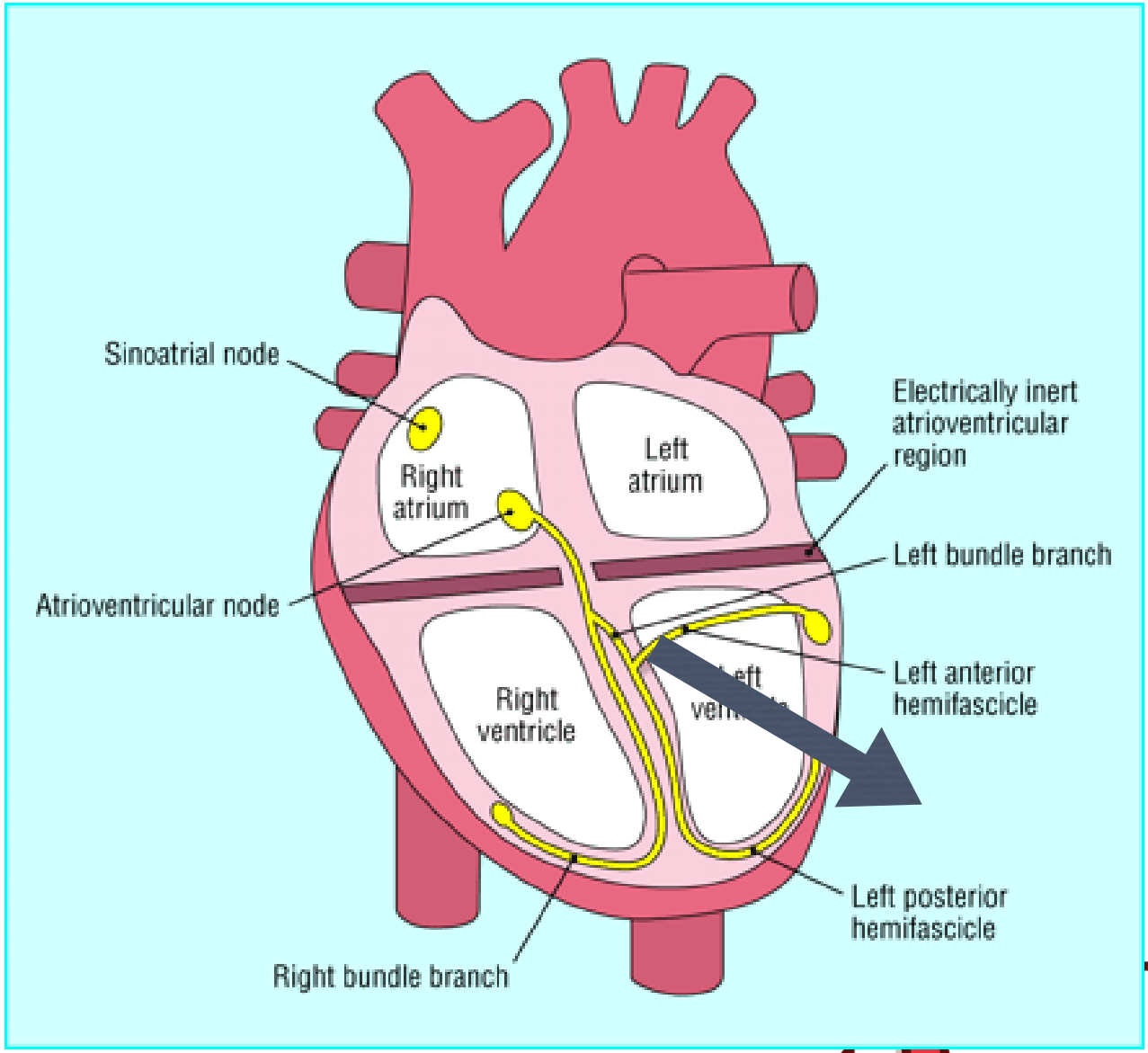
First Phase

- Depolarization of ventricular septum



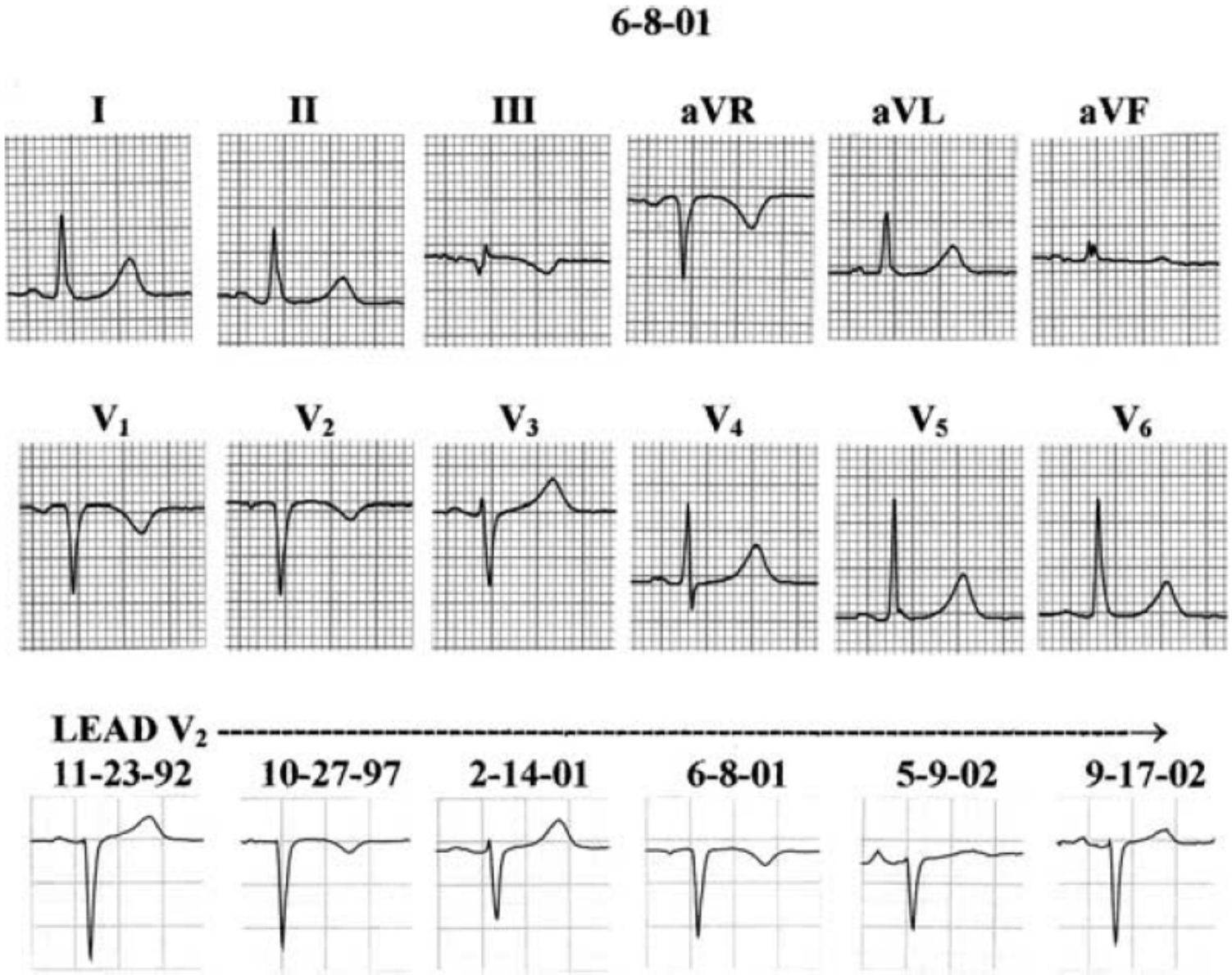
Second Phase

- Depolarization of both ventricles but the left is larger



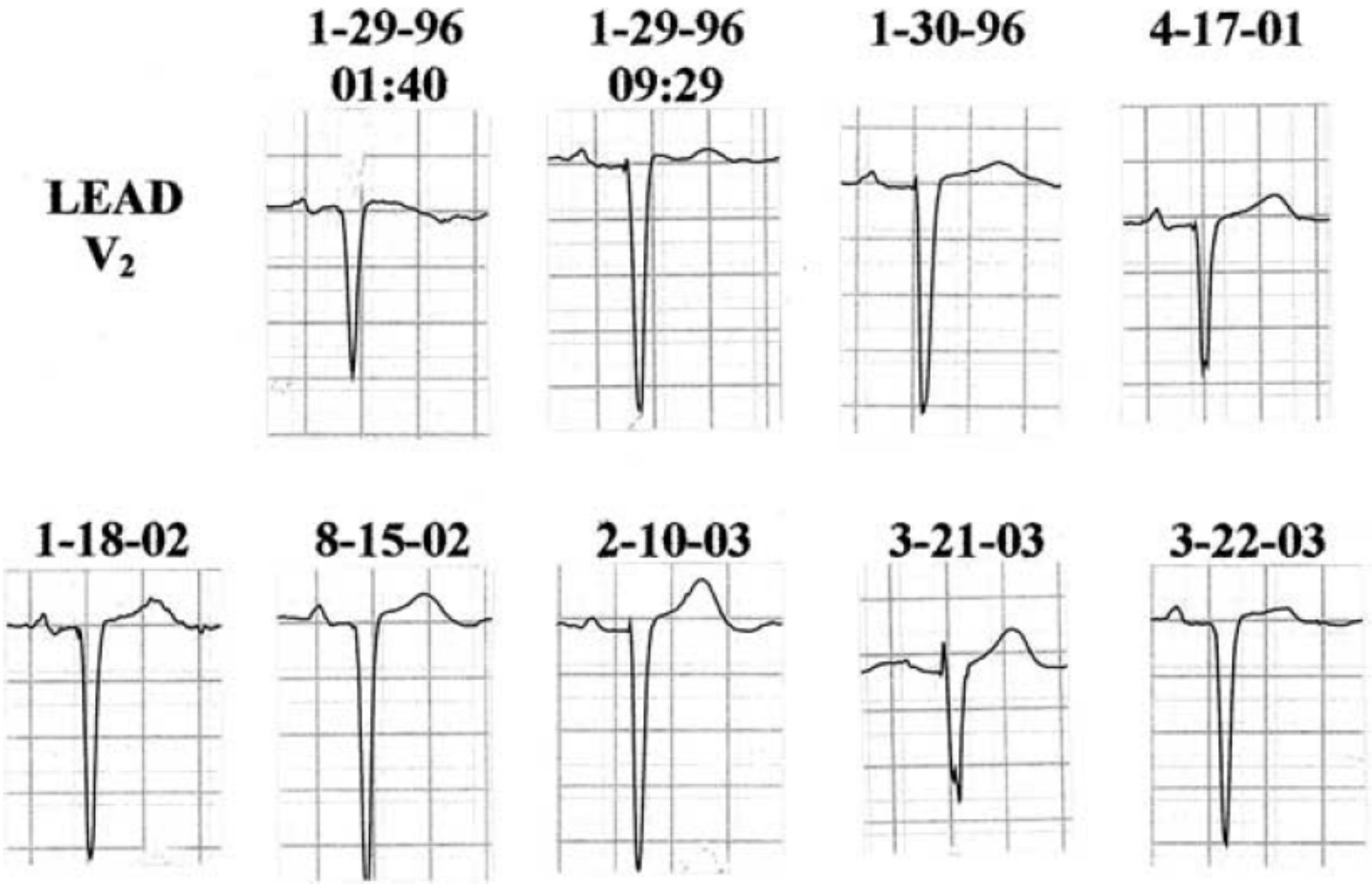
Septal Q waves vs Septal infarct

- QS pattern in lead V1 and V2 can suggest septal MI
- However it can be seen in multiple other conditions (emphysema, obesity, chest deformity etc) and is unreliable indicator of MI
- Look for other ECG abnormalities suggestive of Infarction
- Infarction limited to the interventricular septum is very rare
- When QS deflections in V1 and V2 are accompanied by other ECG abnormalities, especially ischemic-type precordial T wave inversions, the probability of underlying MI is greatly increased.
- Septal Q waves are seen commonly due to improper lead position



ECG of a 74-year-old woman with no evidence of cardiovascular disease.

Lead V2 from multiple ECGs over a 10-year period showed varying morphologies from QS to rS, suggesting changes due to varying right precordial lead placement.



Lead V2 from multiple ECGs over a period of 7 years showed QRS morphology varying from QS to qrS to rS. Interpretations of ECGs ranged from “septal infarction” to “within normal limits.”

Outline

- ECG Basics

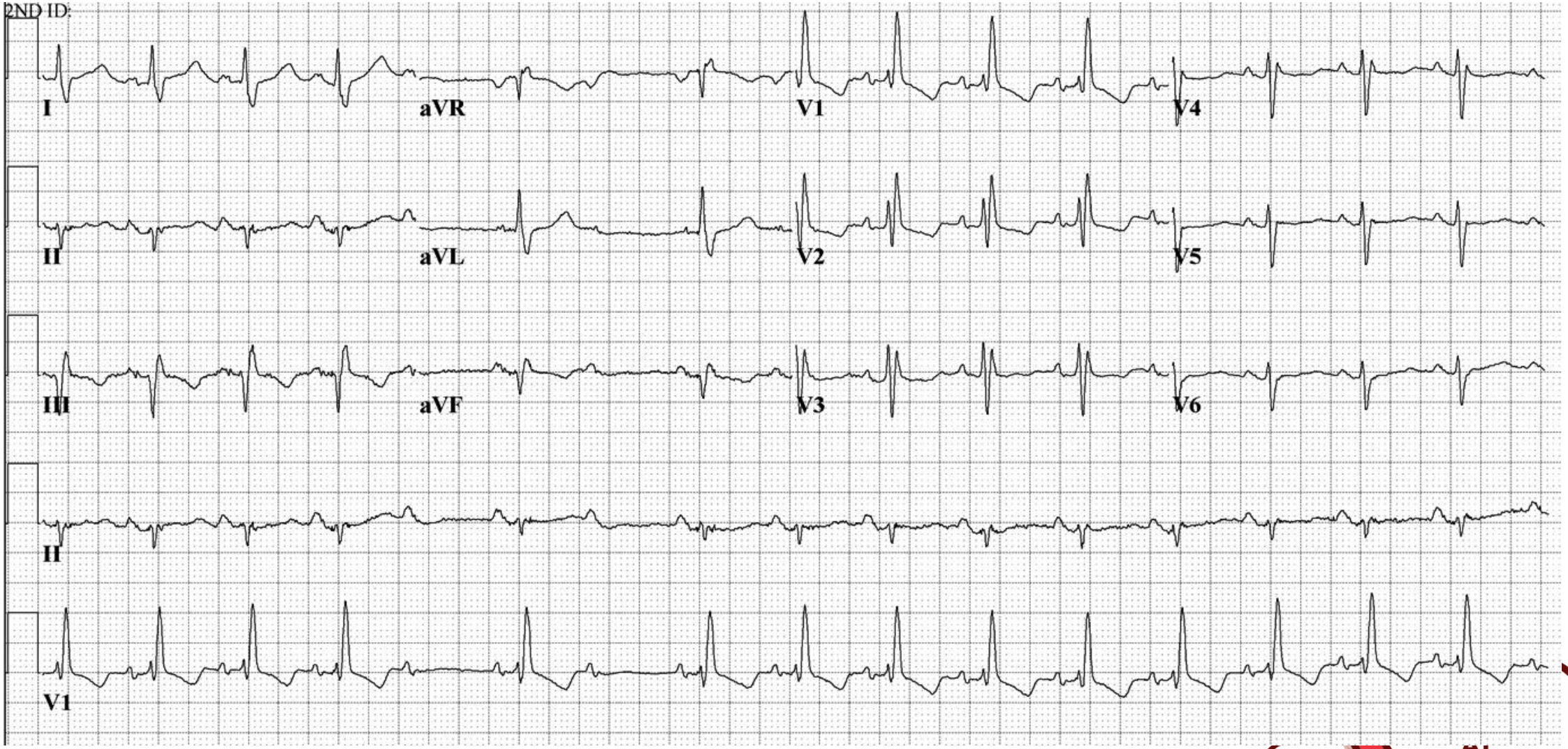
- Common ECG Missteps
  - Old infarct
  - Heart blocks
  - Wide complex tachycardia
  - ST elevation on ECG

- Common Telemetry Missteps
  - Artifact
  - Inaccurate HR

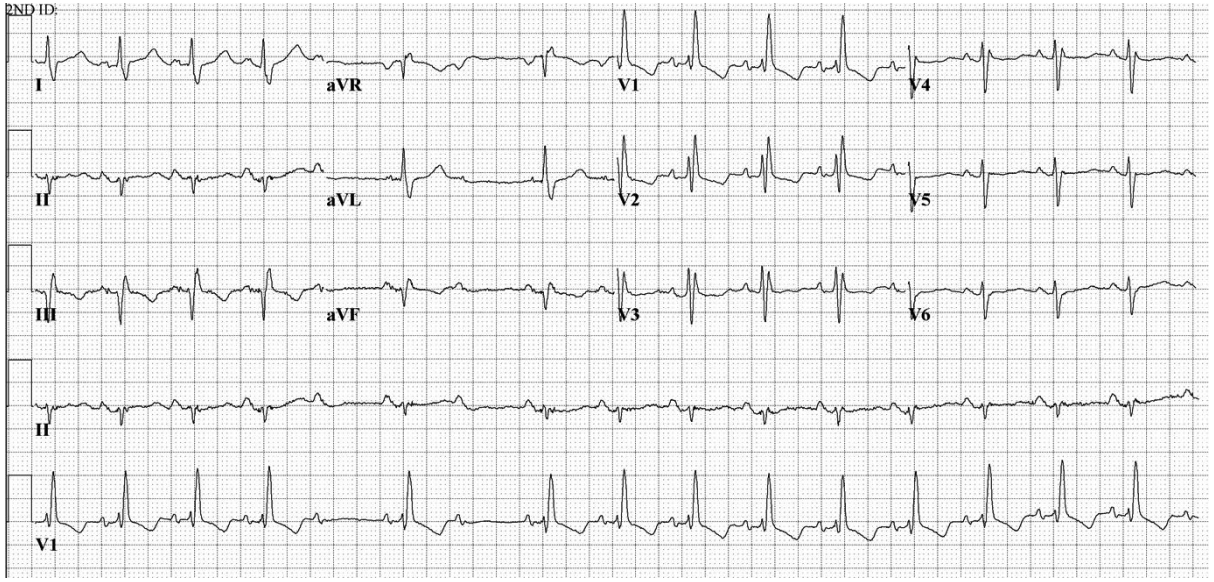
AV Heart Block

48

What is the type of heart block?

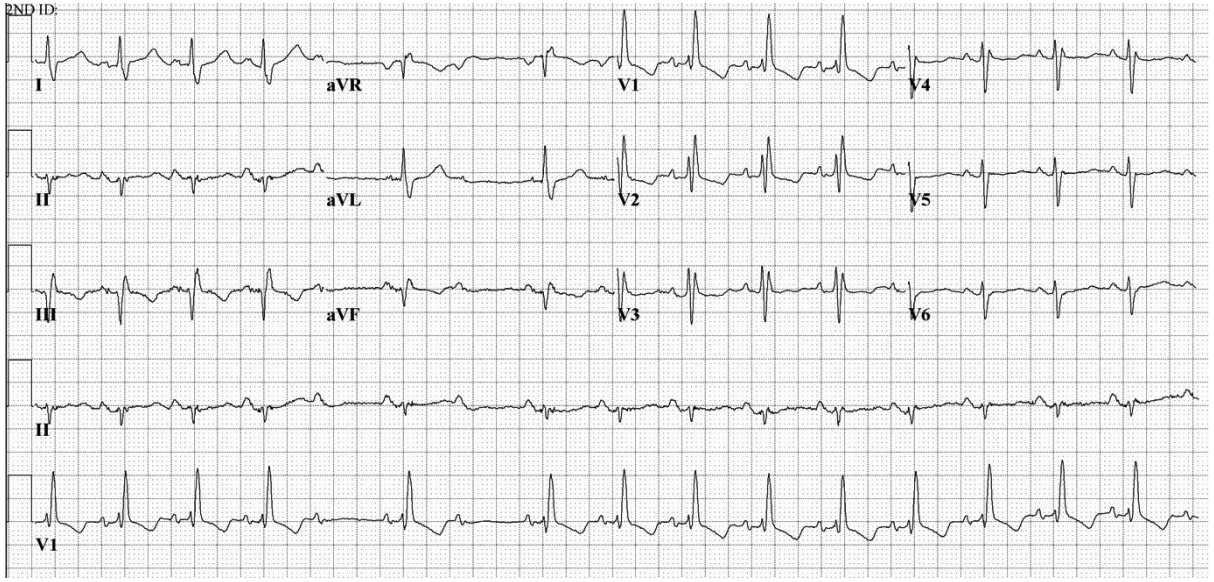


What is the type of heart block?



1. Second degree . Mobitz type 1 (Wenckebach)
2. Second degree . Mobitz Type 2
3. Blocked PAC
4. Cannot say which type of second degree heart block

What is the type of heart block?



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Classification of AV Heart Blocks

Degree	***AV Conduction Pattern***
1St Degree Block	*Uniformly prolonged PR interval*

First Degree Block

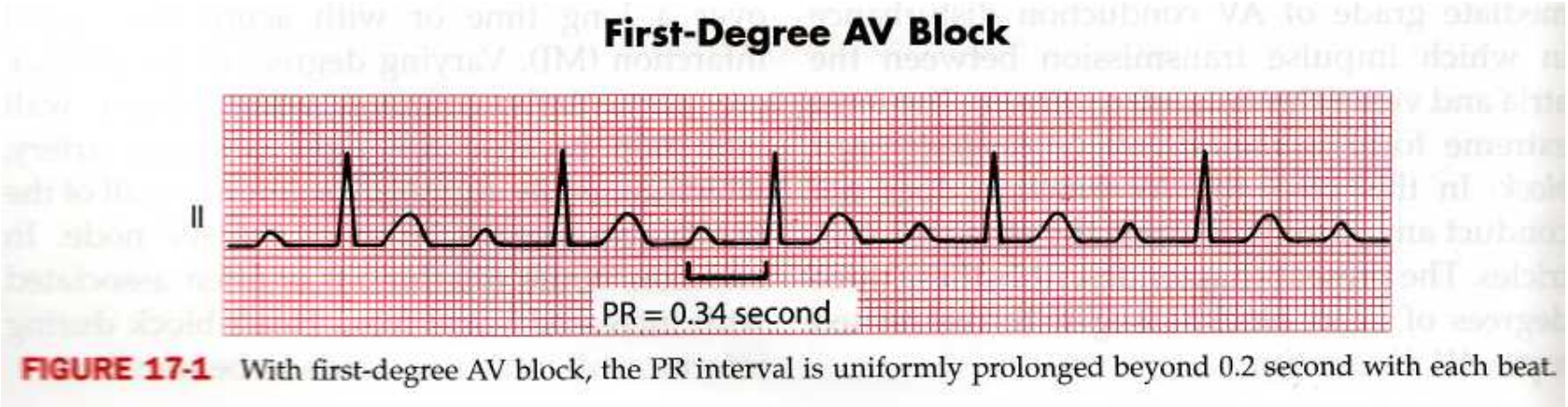


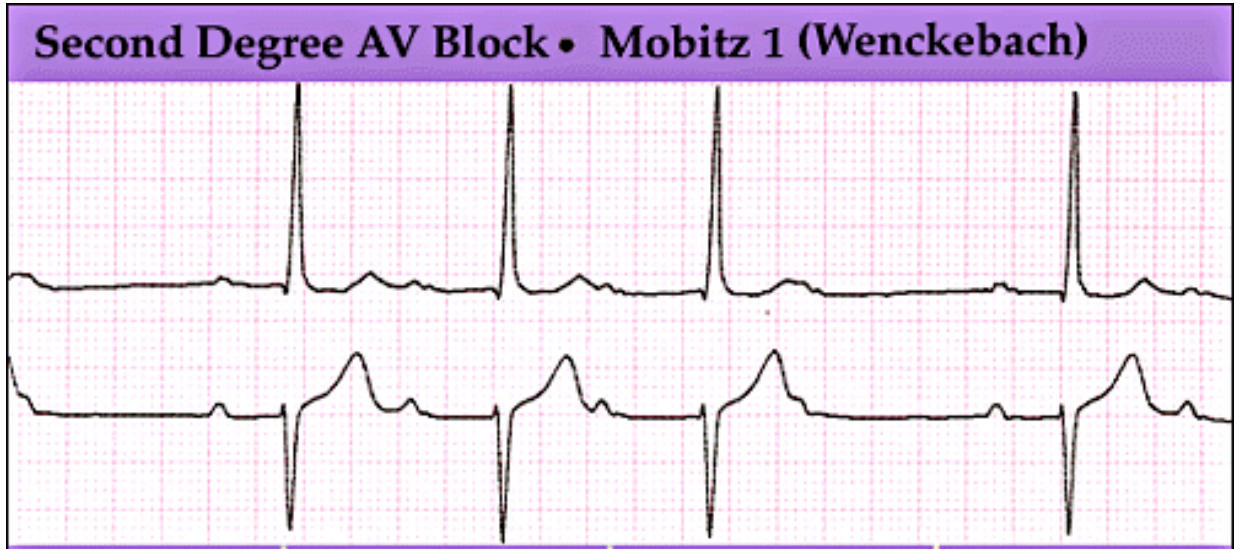
FIGURE 17-1 With first-degree AV block, the PR interval is uniformly prolonged beyond 0.2 second with each beat.

Note the prolonged PR interval

Classification of AV Heart Blocks

Degree	***AV Conduction Pattern***
1St Degree Block	*Uniformly prolonged PR interval*
2nd Degree, Mobitz Type I	*Progressive PR interval prolongation*

Second Degree AV Block Type I or Wenckebach



P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Conduction intermittant	Increasingly Prolonged	<.12	QRS dropped in a repeating pattern

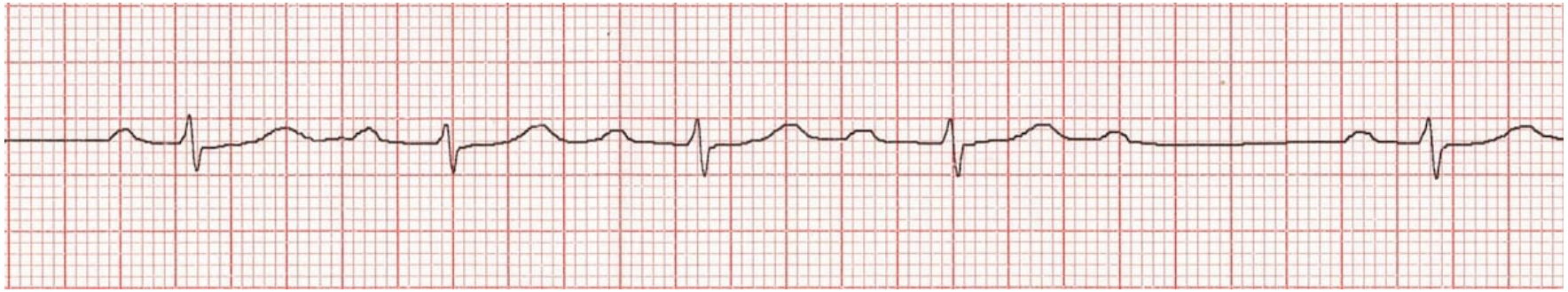
Second Degree AV Block - Type I Wenckebach

1. Progressive lengthening of the PR interval from beat to beat until a beat is dropped.

2. The PR interval after the nonconducted P wave is shorter than the PR interval before the nonconducted P wave.

3. May be grouping of QRS complexes

What is this ?



Classification of AV Heart Blocks

Degree	***AV Conduction Pattern***
1St Degree Block	*Uniformly prolonged PR interval*
2nd Degree, Mobitz Type I	*Progressive PR interval prolongation*
2nd Degree, Mobitz Type II	*Sudden conduction failure*

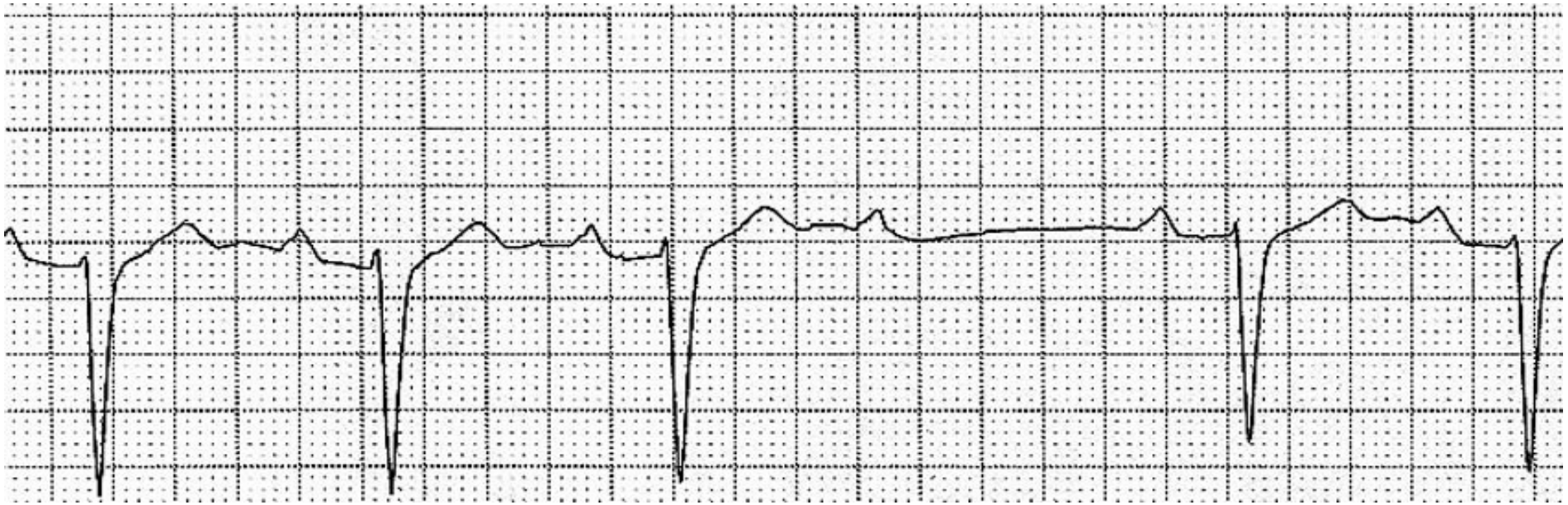
Second Degree AV Block

Type II

1. Sudden appearance of a single, non-conducted sinus P wave.

2. Without
    1. Progressive prolongation of the PR intervals
    2. And shortening of the PR interval in the beat after the non-conducted P wave.

Second Degree AV Block
Type II

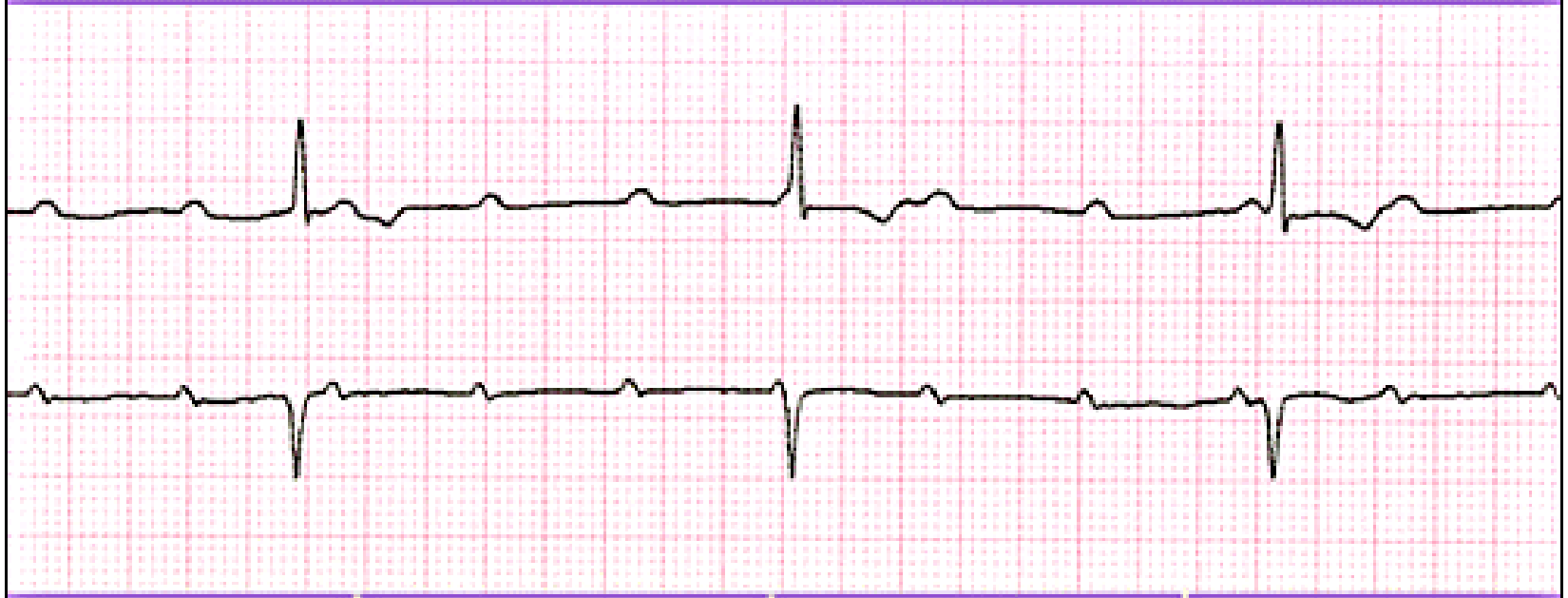


2:1 AV Blocks

- Often are type II blocks
  - look for slightly prolonged QRS
- They can be type I blocks
  - look at long rhythm strip
- Sometimes they are labelled a “second degree block” only

Third-Degree (Complete) AV Block

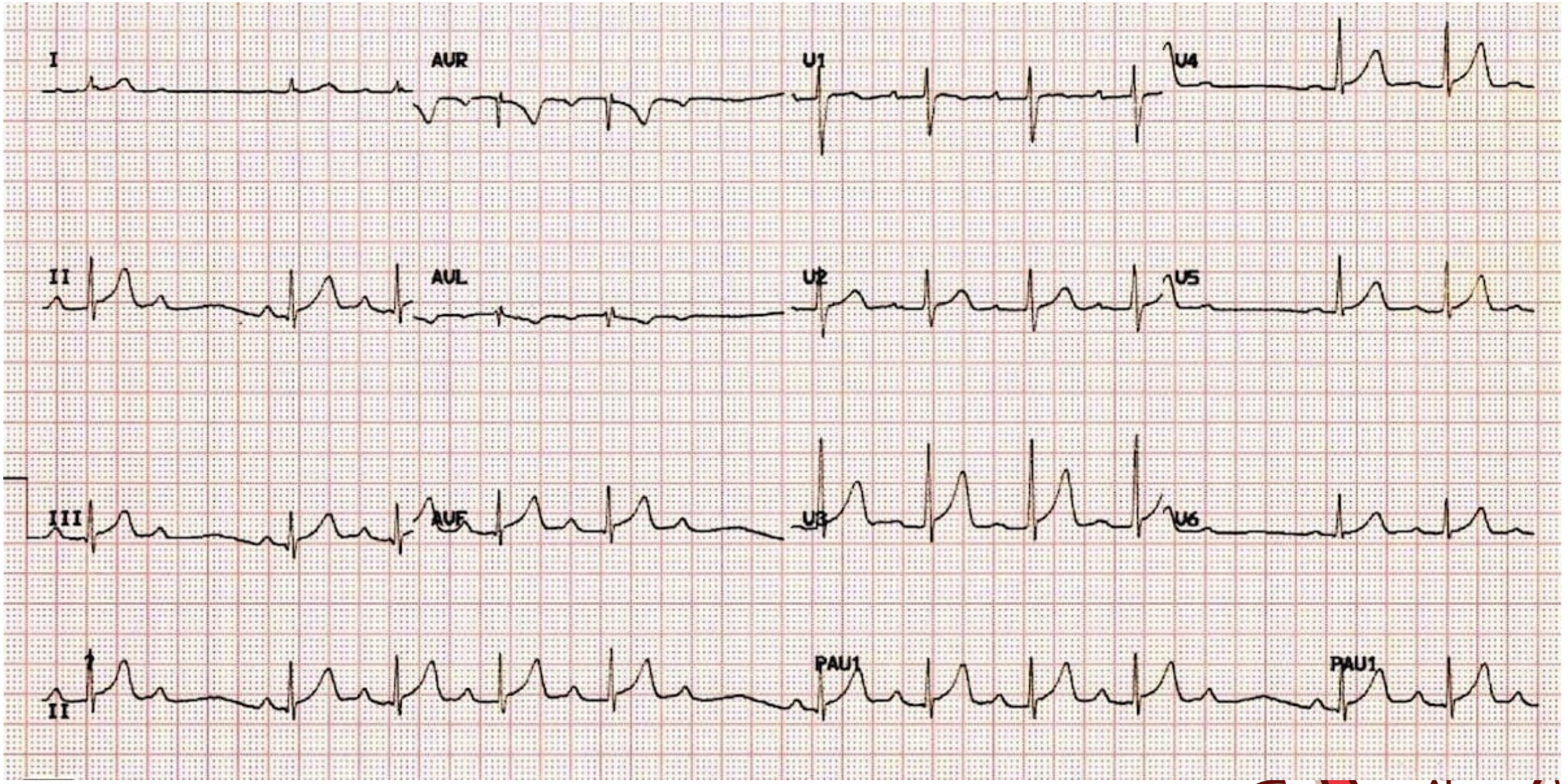
Third Degree (complete) AV Block



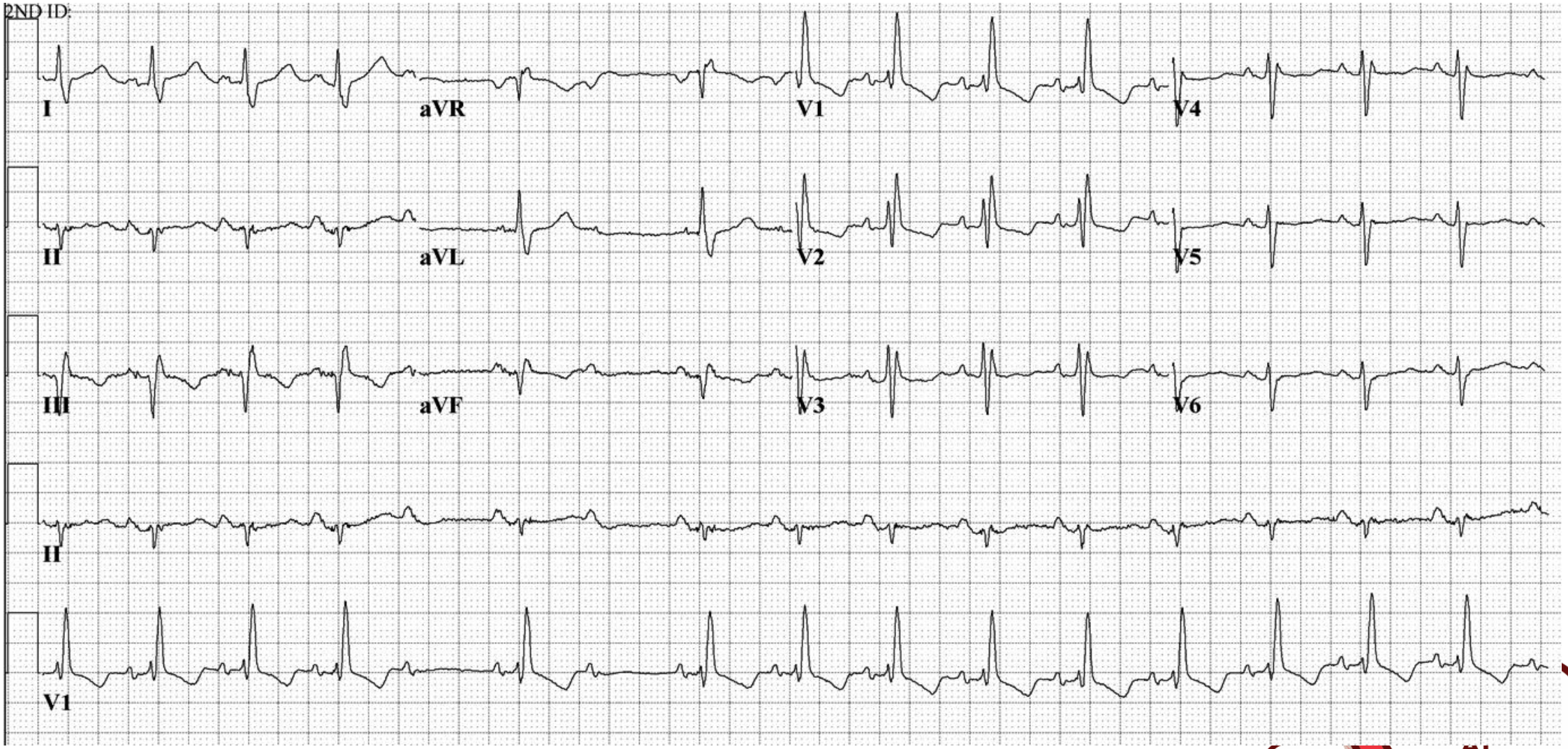
P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Normal but not related to QRS	None	N/A	No relationship between P&RS

Third-Degree (Complete) AV Block

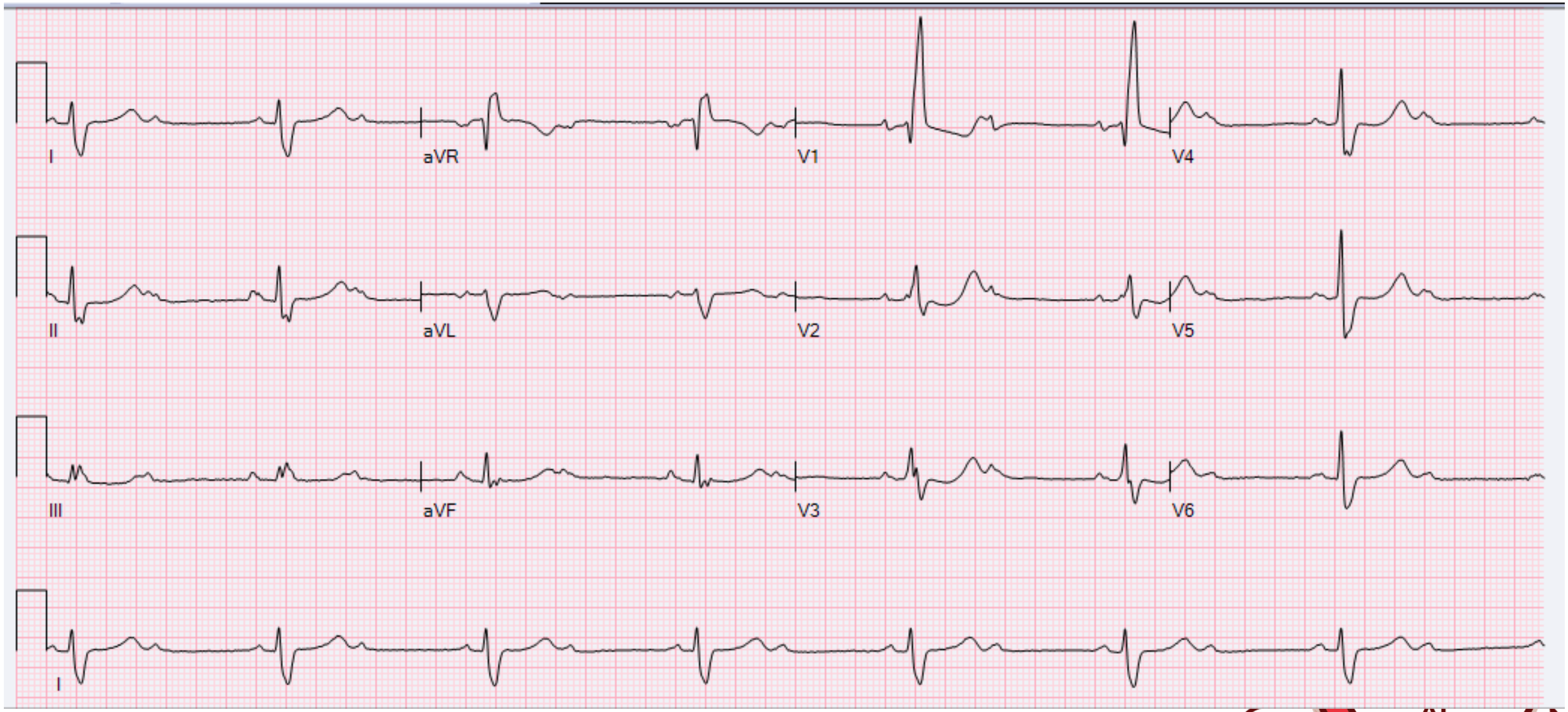
1. P waves are present, with a regular atrial rate faster than the ventricular rate
2. QRS complexes are present, with a slow (usually fixed) ventricular rate
3. The P wave bears no relation to the QRS complexes, and the PR intervals are completely variable
4. (Some properly timed P waves may be conducted)


I
AUR
U1
U4
II
AUL
U2
U5
III
AUF
U3
U6
II
PAU1
PAU1

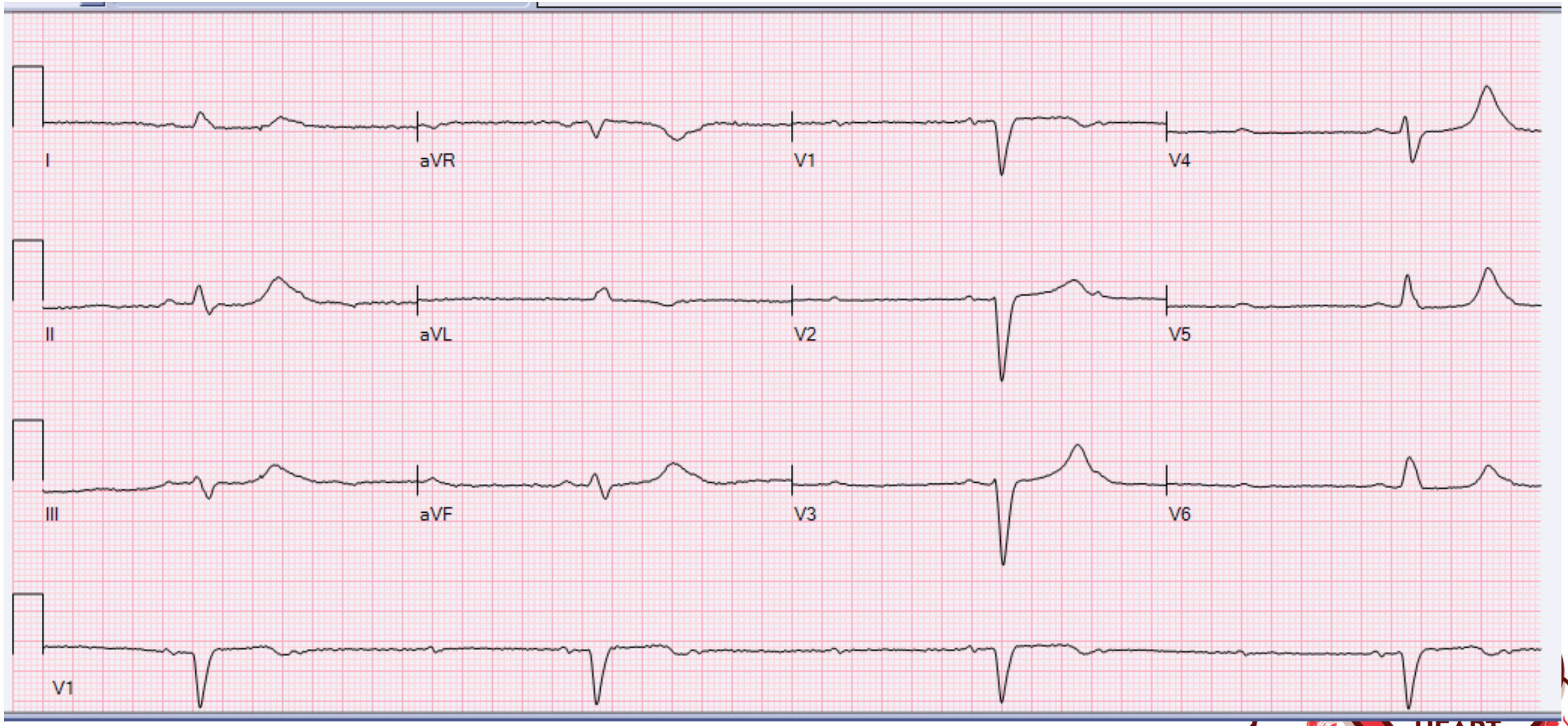
What is this ?



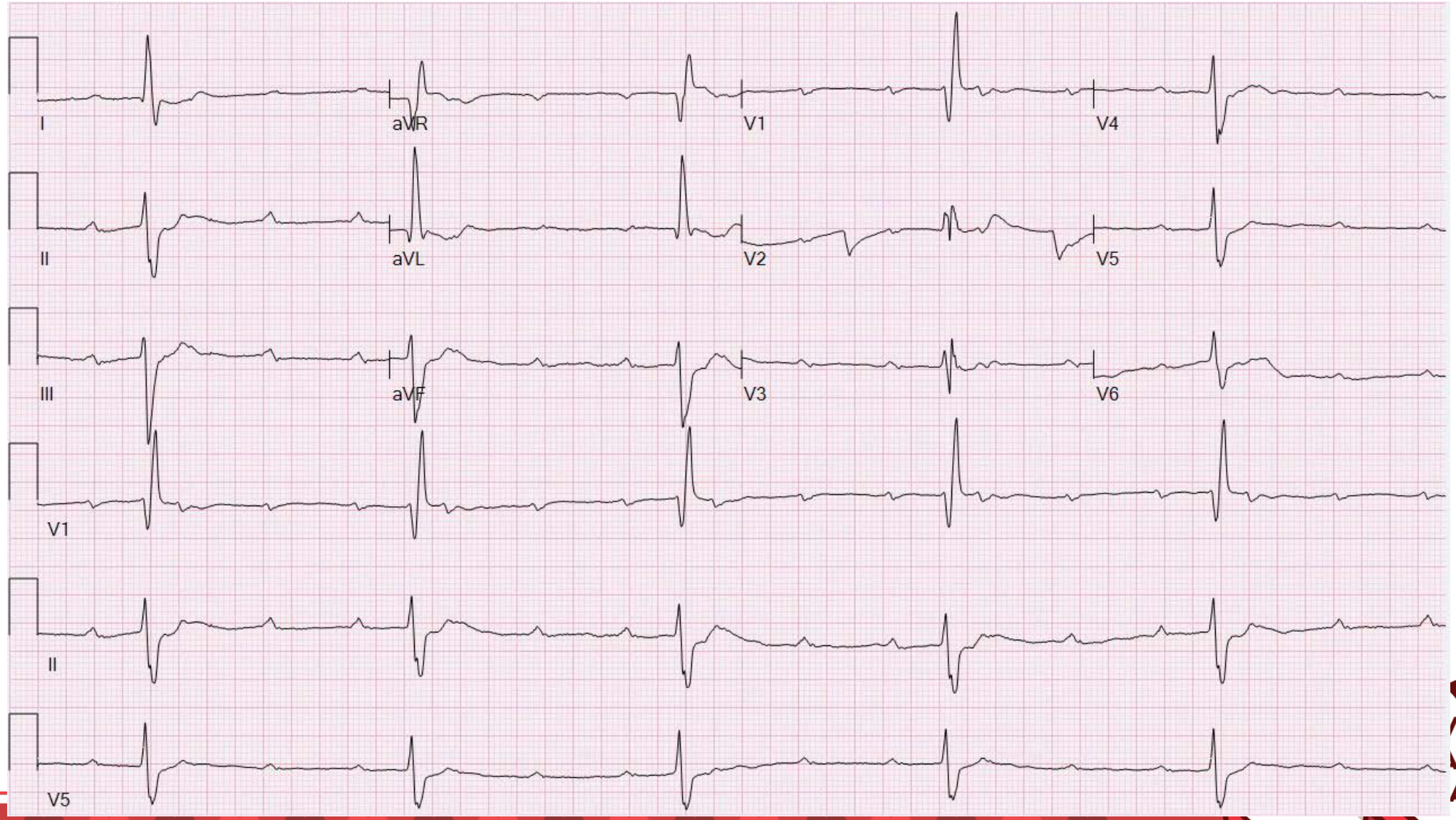
What is this ?



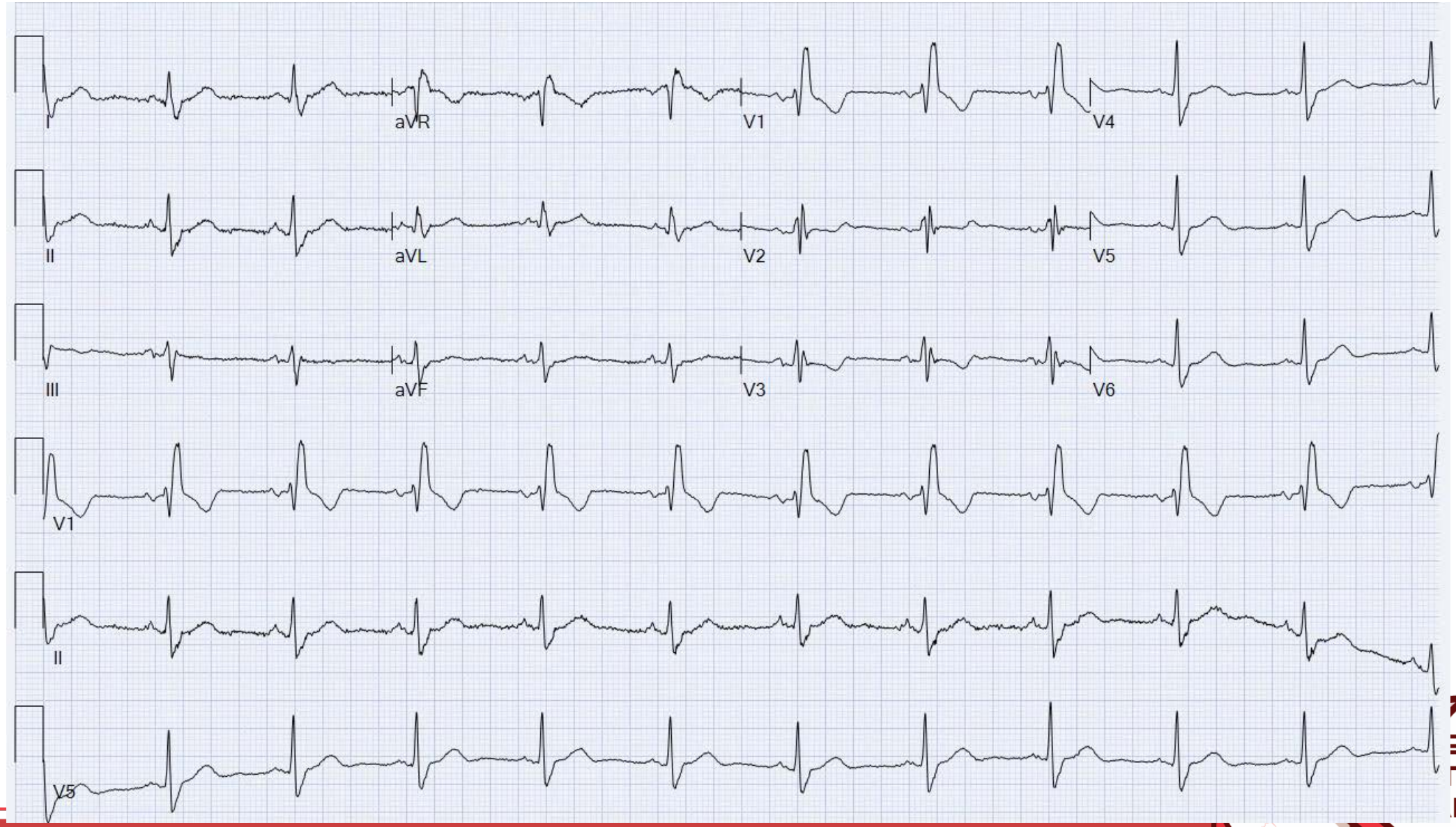
What is this ?

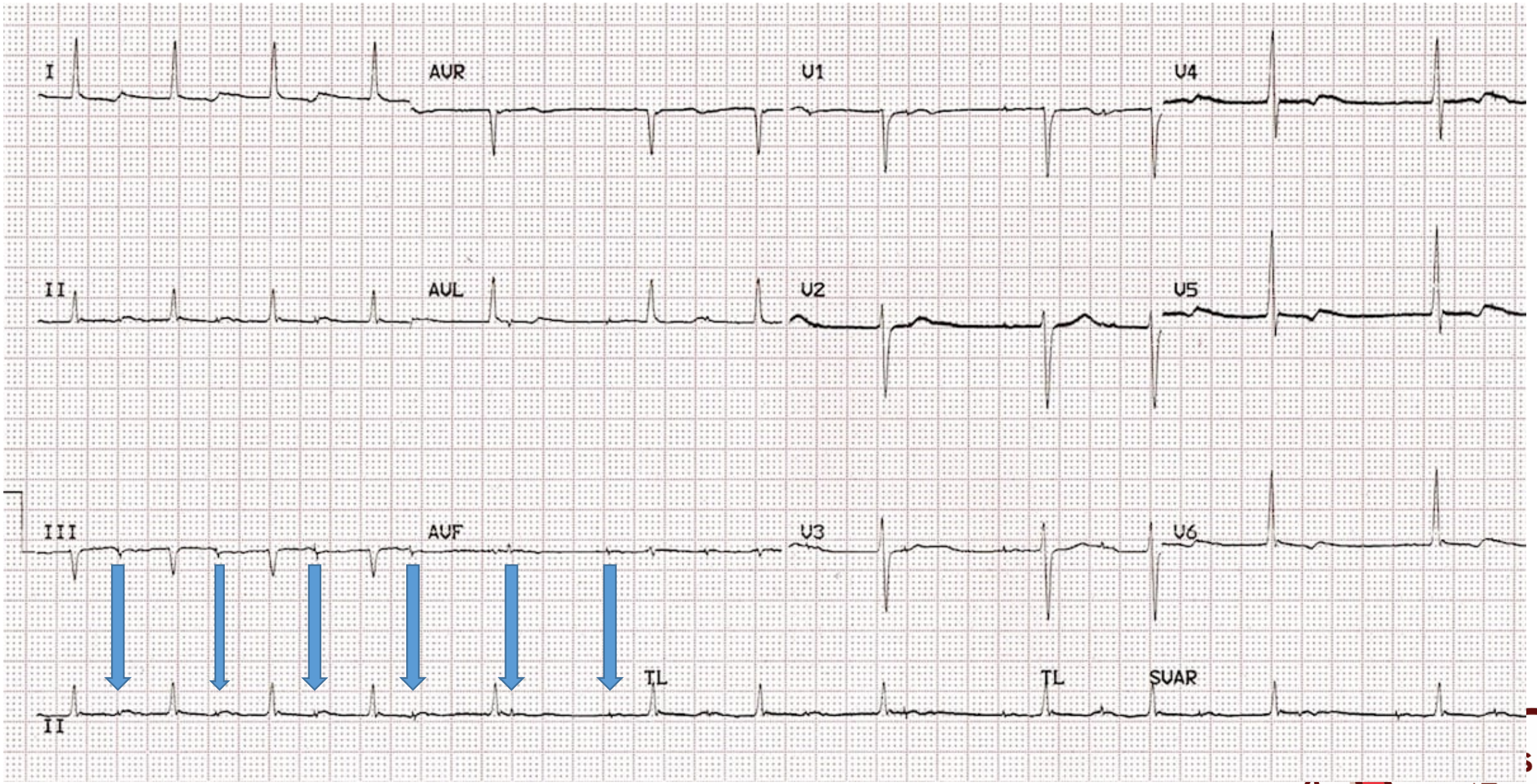


What is this ?



ECG from 2014



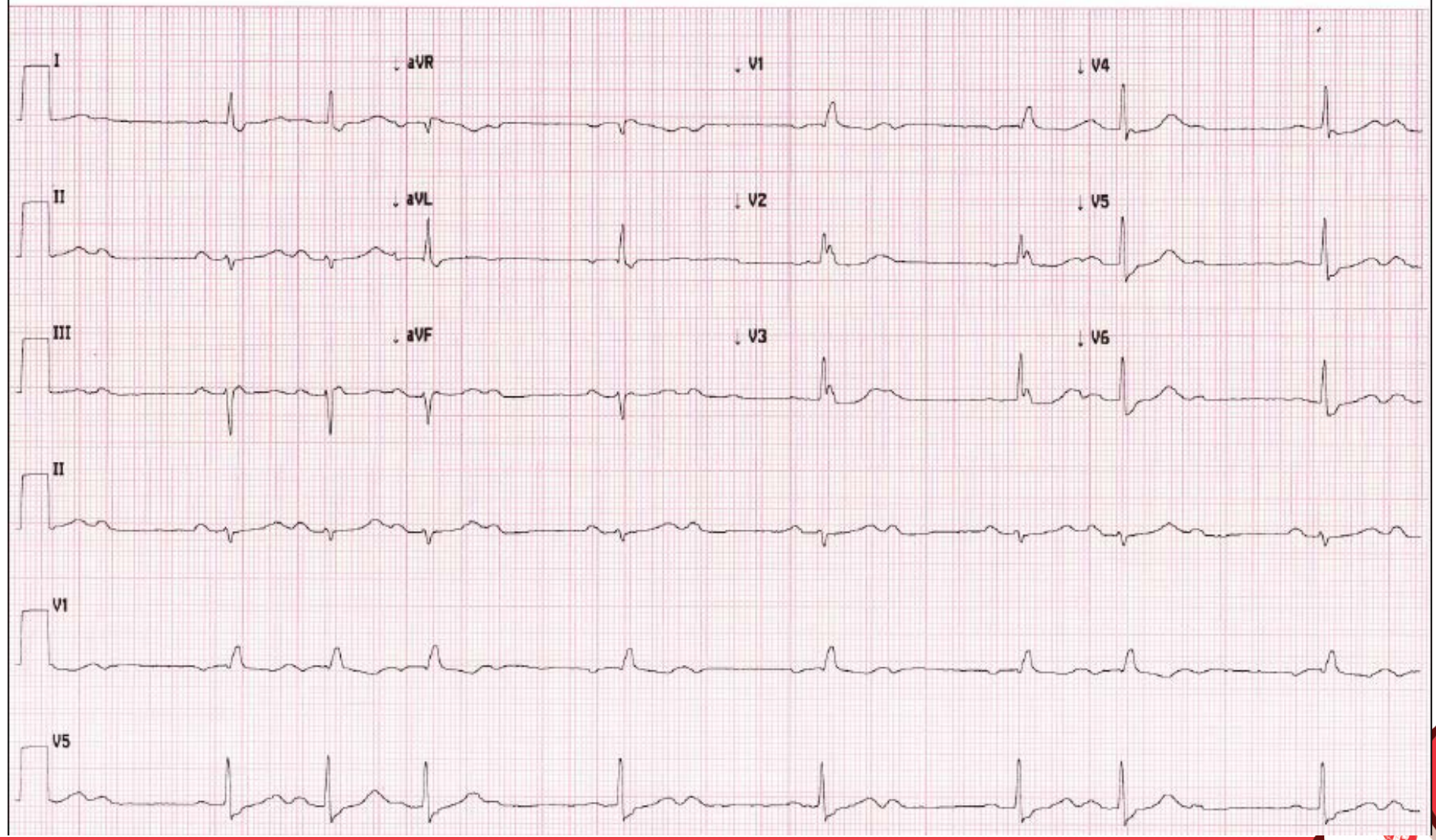

I
AUR
U1
U4
II
AUL
U2
U5
III
AUF
U3
U6
IL
TL
SUAR
II

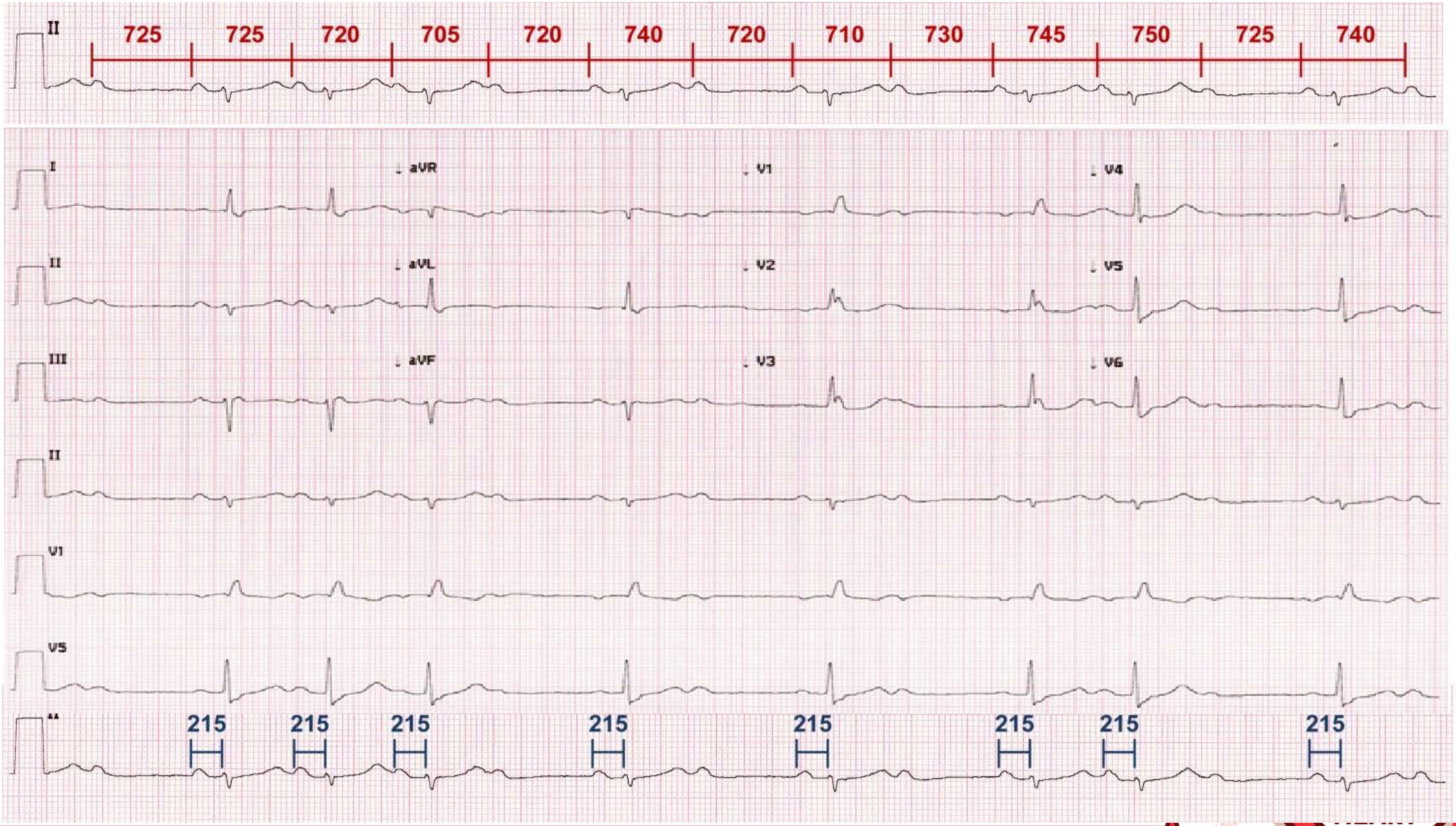
84years
Male

Vent rate:	52 BPM
PR int:	224 ms
QRS dur:	147 ms
QT/QTc:	550/530 ms
P-R-T axes:	77 -43 62

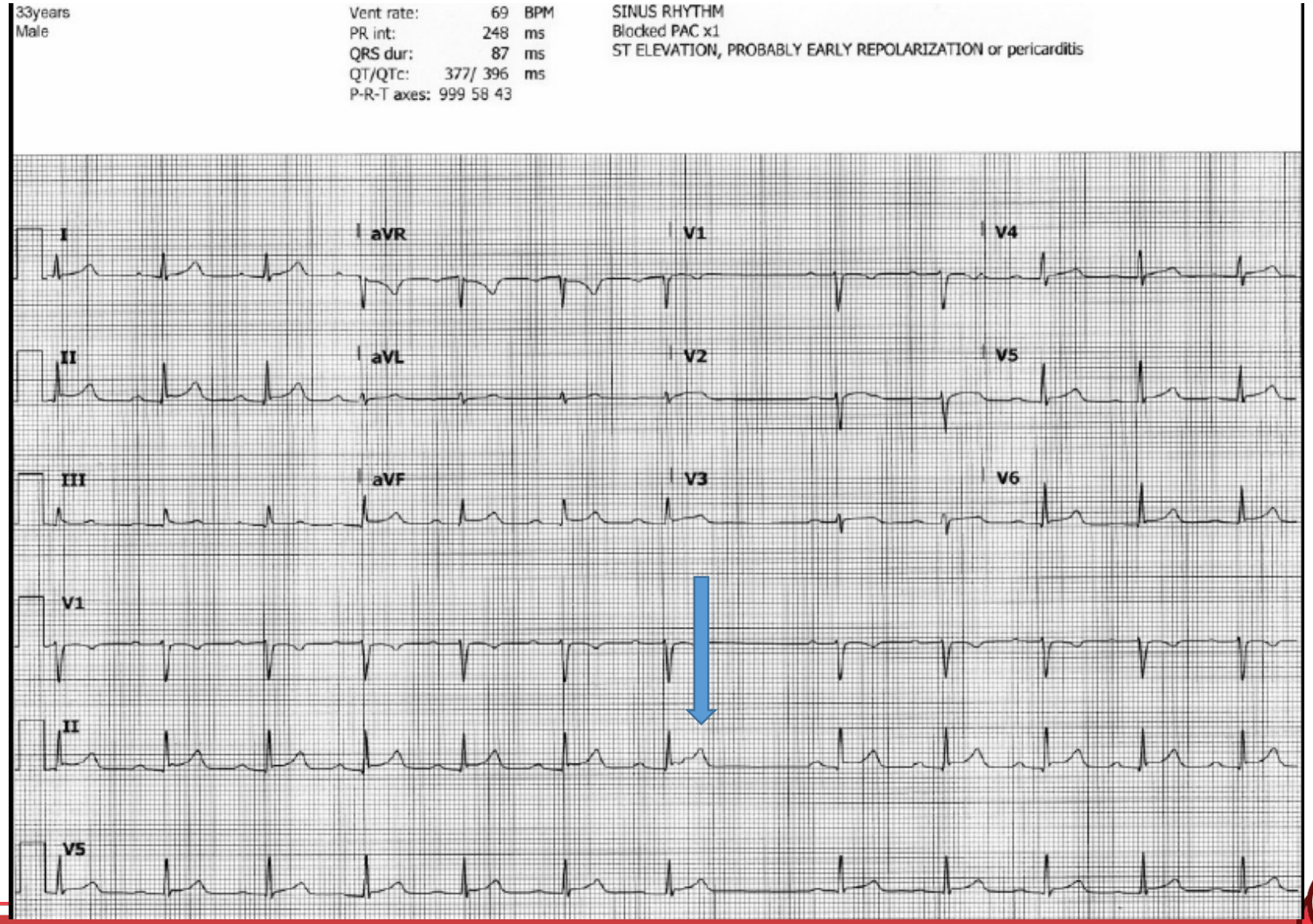
SINUS BRADYCARDIA WITH PROLONGED PR INTERVAL WITH FREQUENT SUPRAVENTRICULAR PREMATURE COMPLEXES
MARKED LEFT AXIS DEVIATION
RIGHT BUNDLE BRANCH BLOCK
ABNORMAL ECG

UNCONFIRMED REPORT




II
725
725
720
705
720
740
720
710
730
745
750
725
740
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
V1
V5
215
215
215
215
215
215
215
215

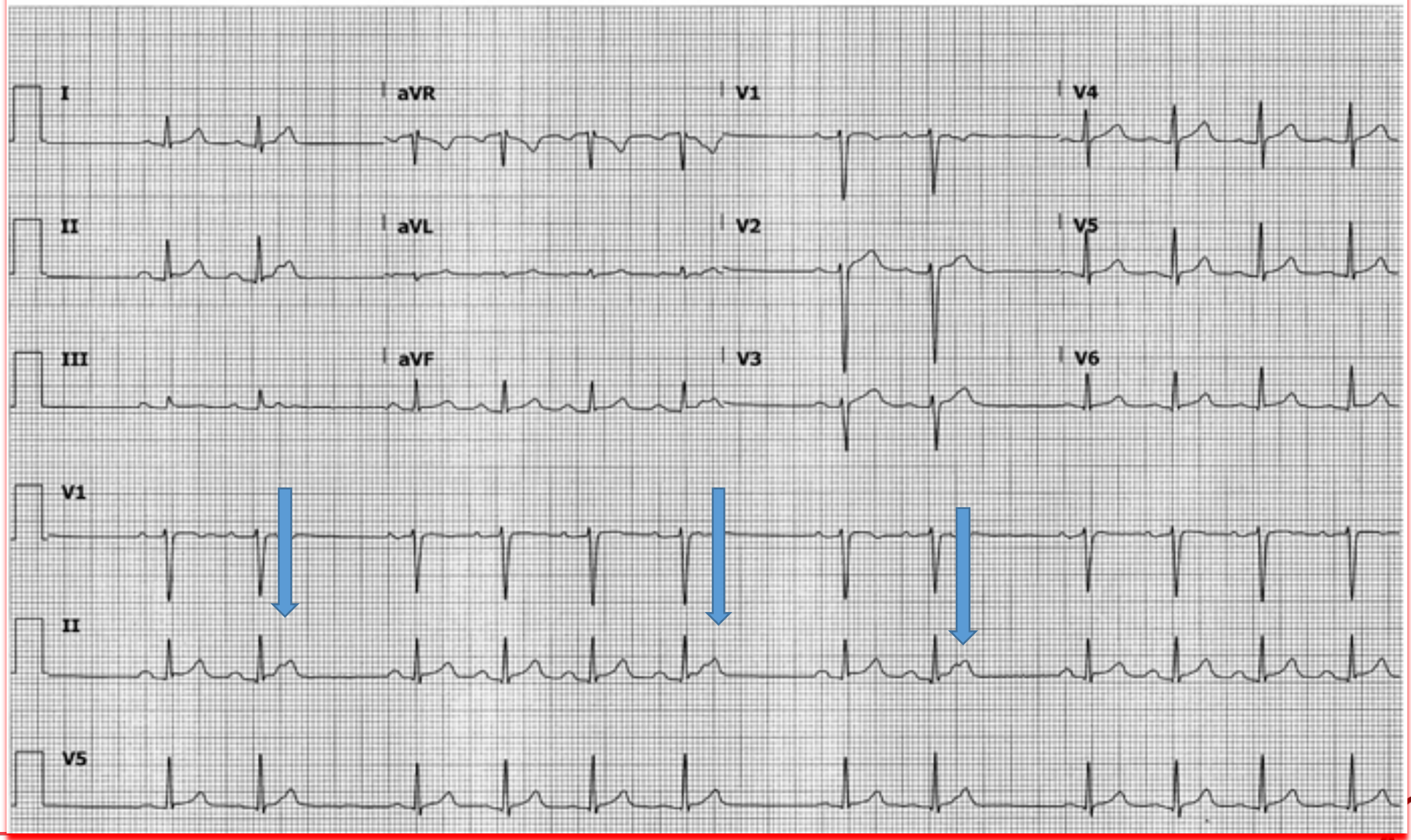
Blocked PAC


33years
Male
Vent rate: 69 BPM
PR int: 248 ms
QRS dur: 87 ms
QT/QTc: 377/ 396 ms
P-R-T axes: 999 58 43
SINUS RHYTHM
Blocked PAC x1
ST ELEVATION, PROBABLY EARLY REPOLARIZATION or pericarditis
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5

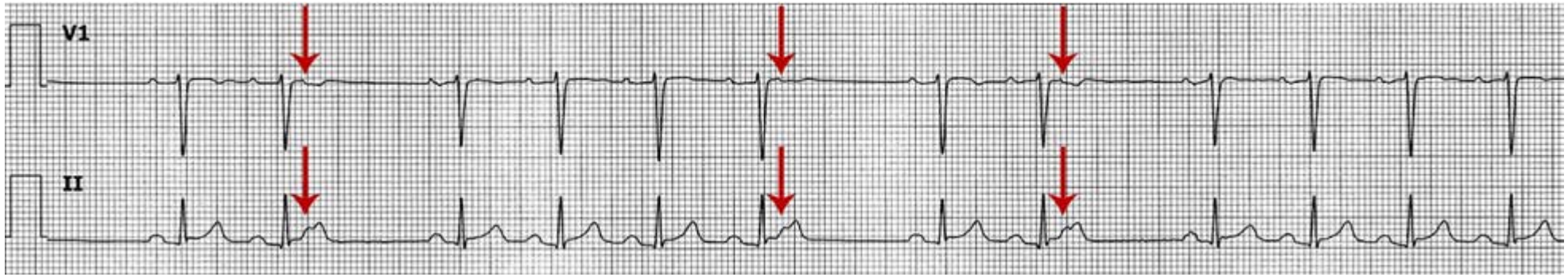
Male

Vent rate:	75	BPM
PR int:	0	ms
QRS dur:	90	ms
QT/QTc:	348/ 377	ms
P-R-T axes:	999 61 33	

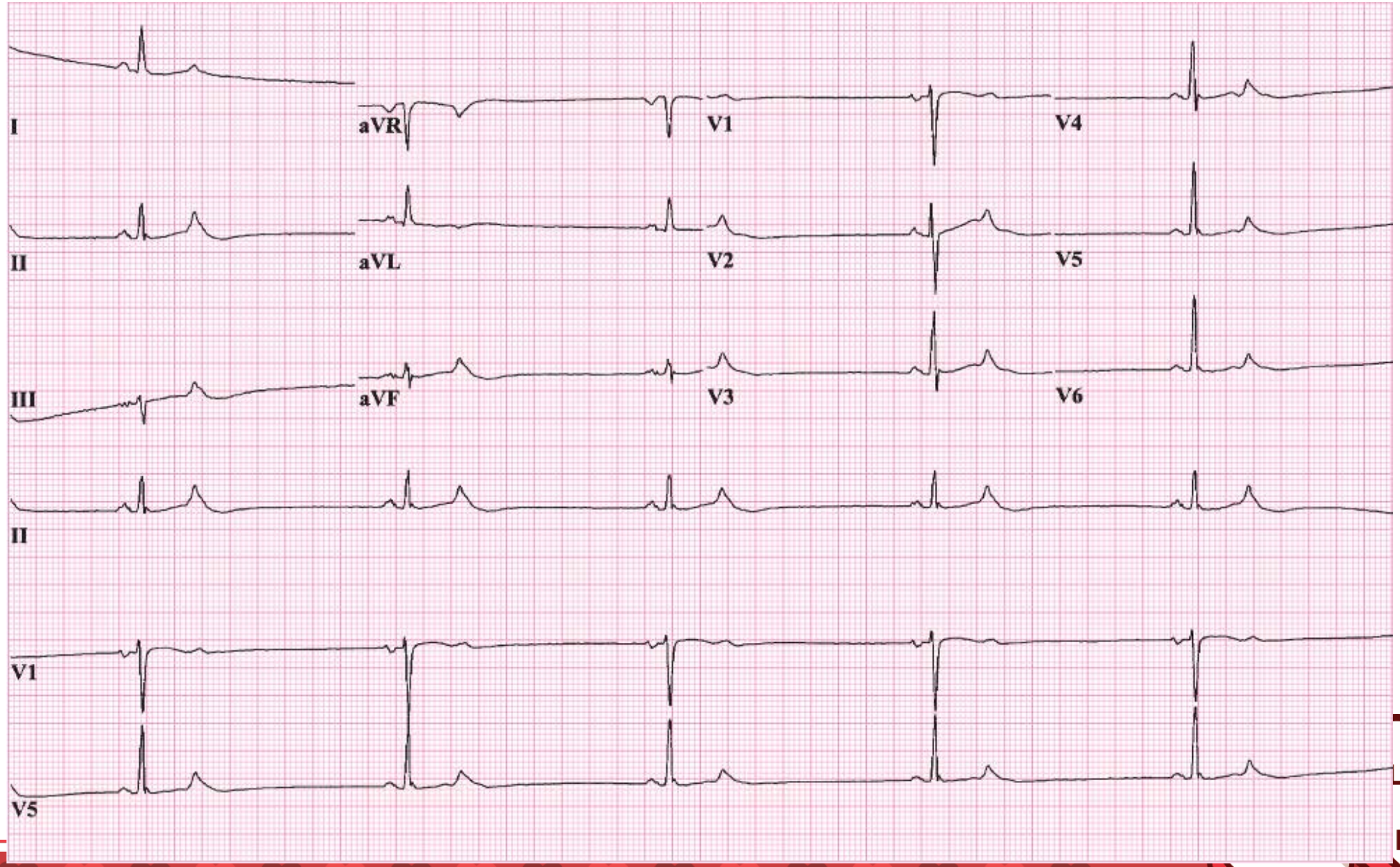
SINUS RHYTHM WITH 2ND DEGREE AV BLOCK, MOBITZ TYPE II
NONSPECIFIC ST ELEVATION
ABNORMAL ECG



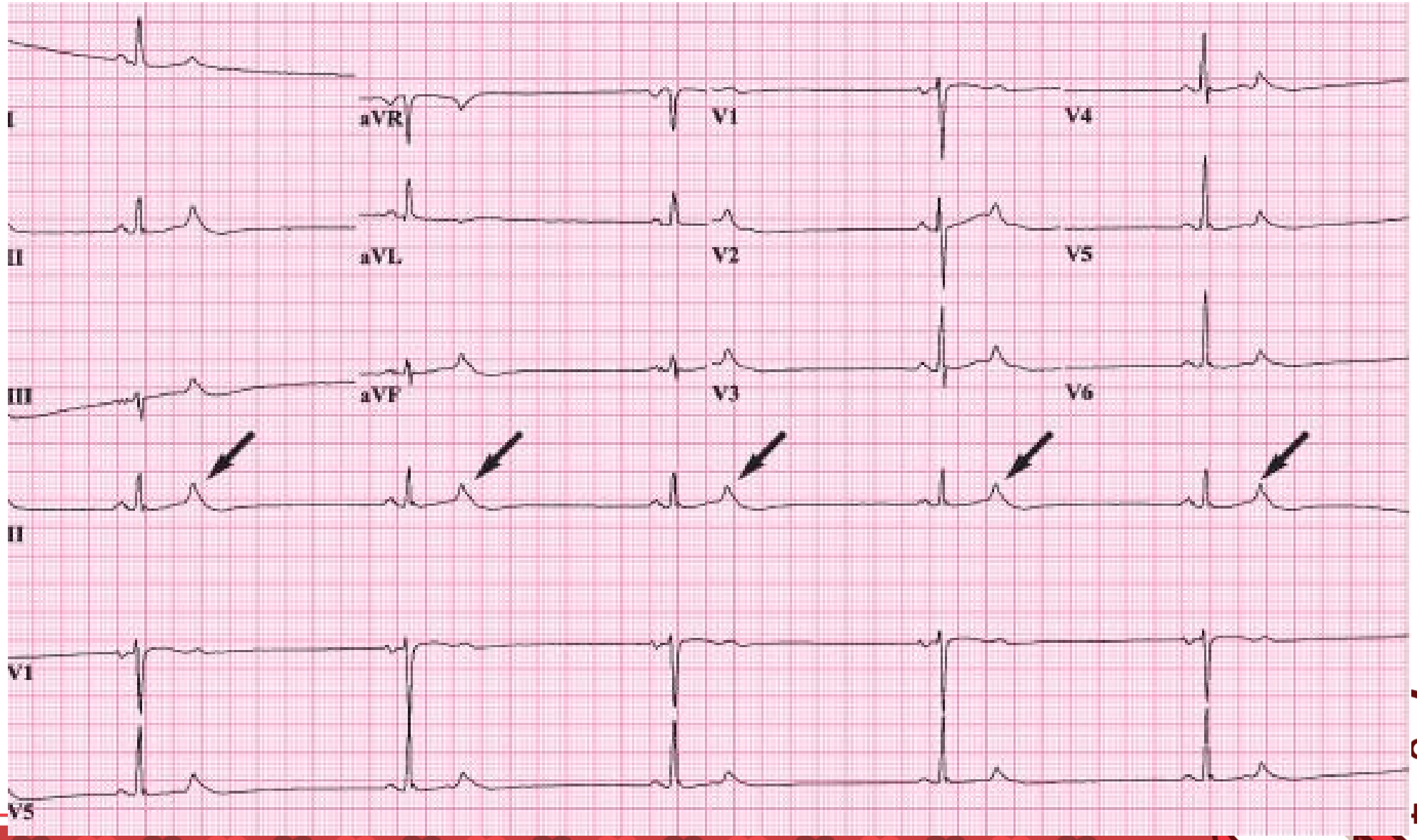
- Blocked PACs



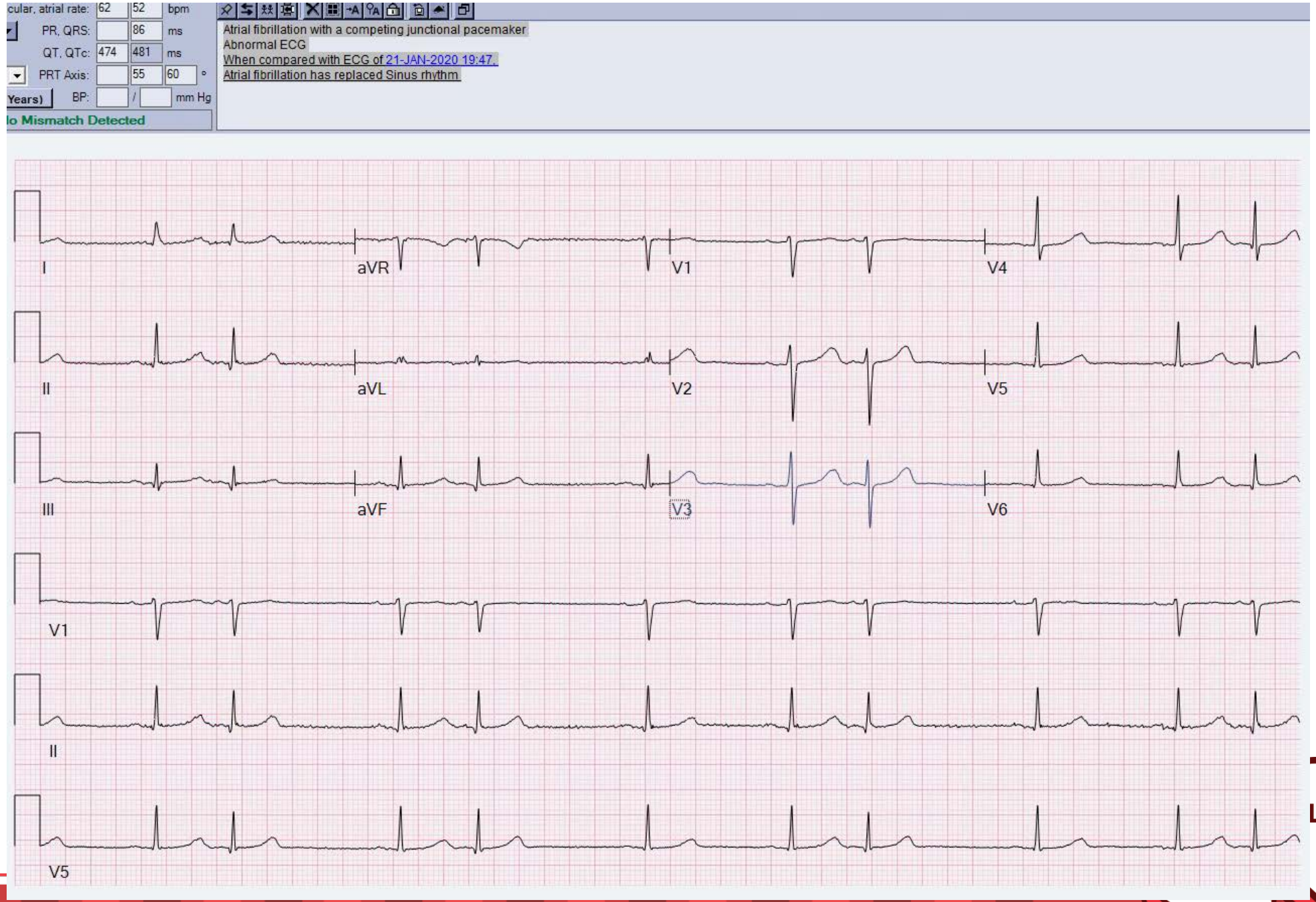
61 year old female with light headedness



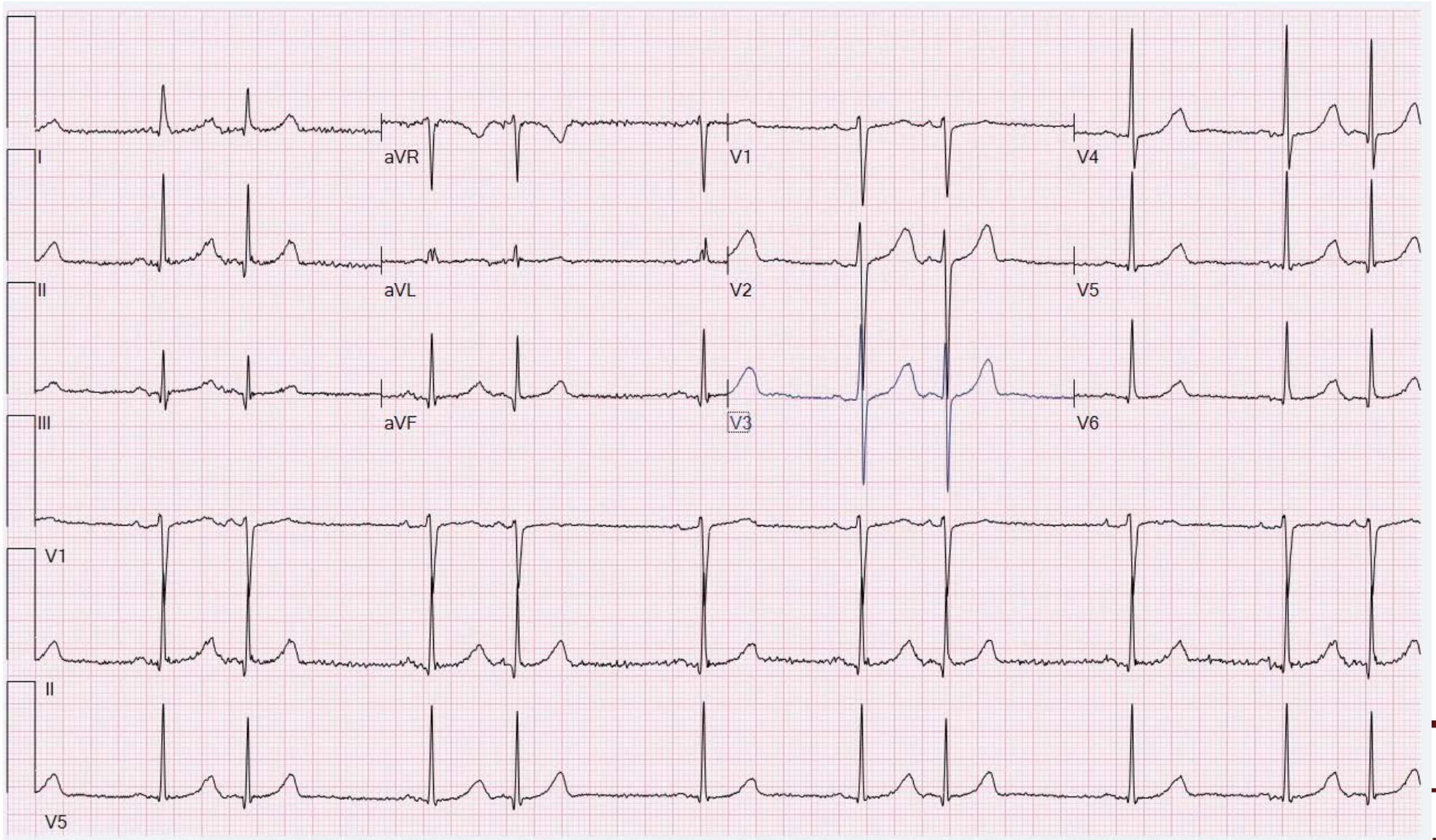
Blocked PACs



Under sensing of P waves by ECG machine leading to inaccurate AF diagnosis


cular, atrial rate: 62 52 bpm
PR, QRS: 86 ms
QT, QTc: 474 481 ms
PRT Axis: 55 60 °
Years) BP: / mm Hg
lo Mismatch Detected
Atrial fibrillation with a competing junctional pacemaker
Abnormal ECG
When compared with ECG of 21-JAN-2020 19:47,
Atrial fibrillation has replaced Sinus rhythm
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5

Limb lead gain was increased. Can see P waves



Look for P waves

Sinus arrhythmia

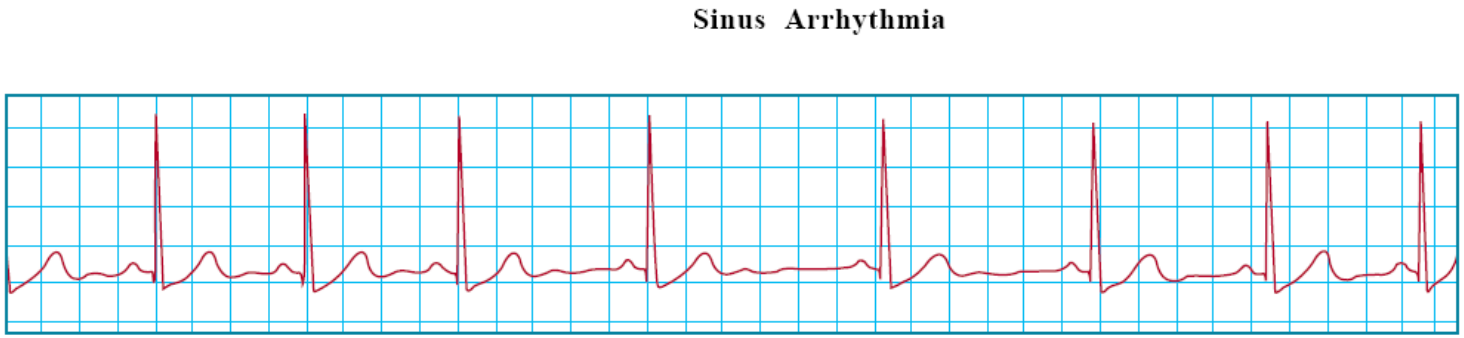


Figure by MIT OCW.

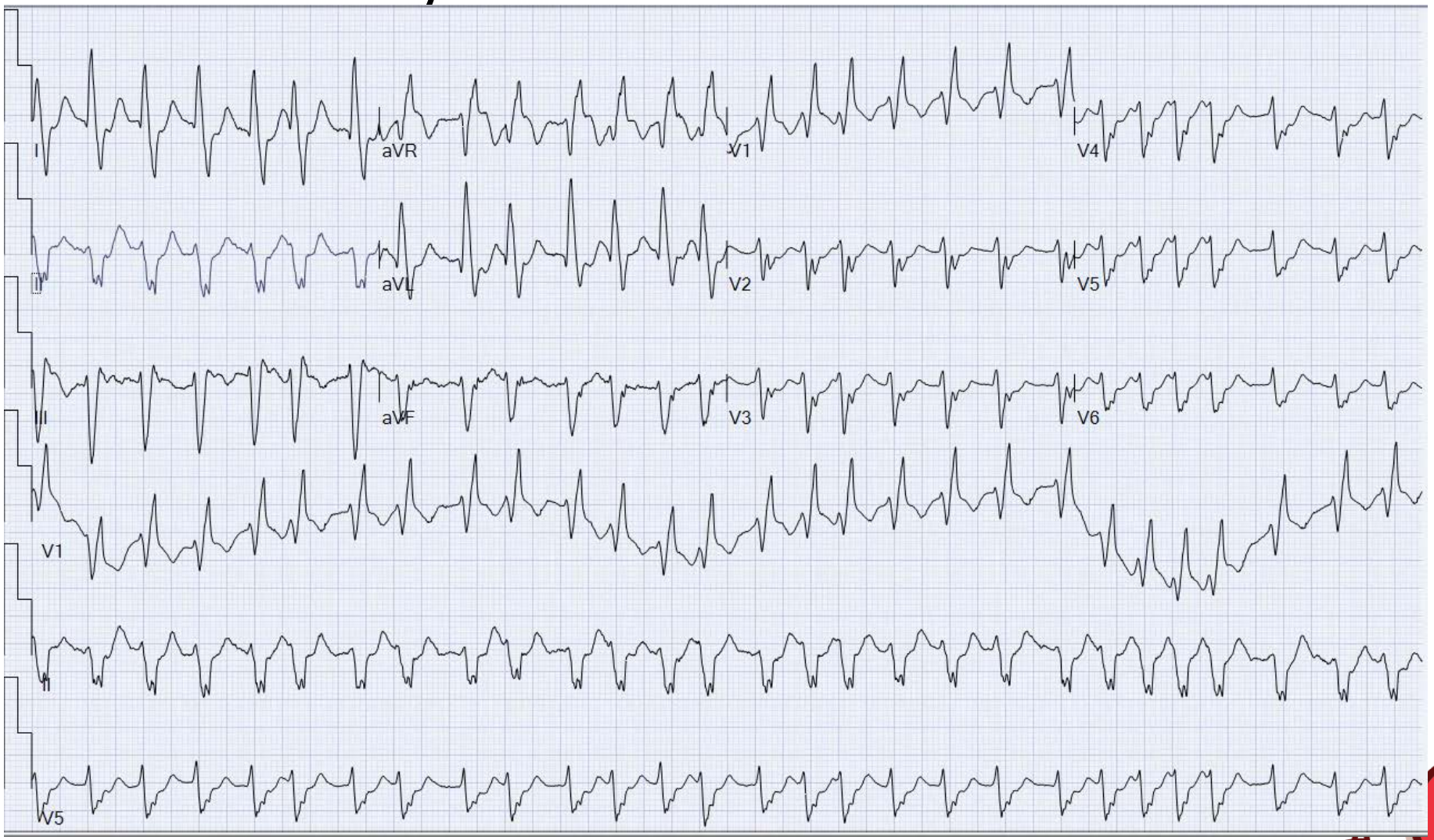
Outline

- ECG Basics

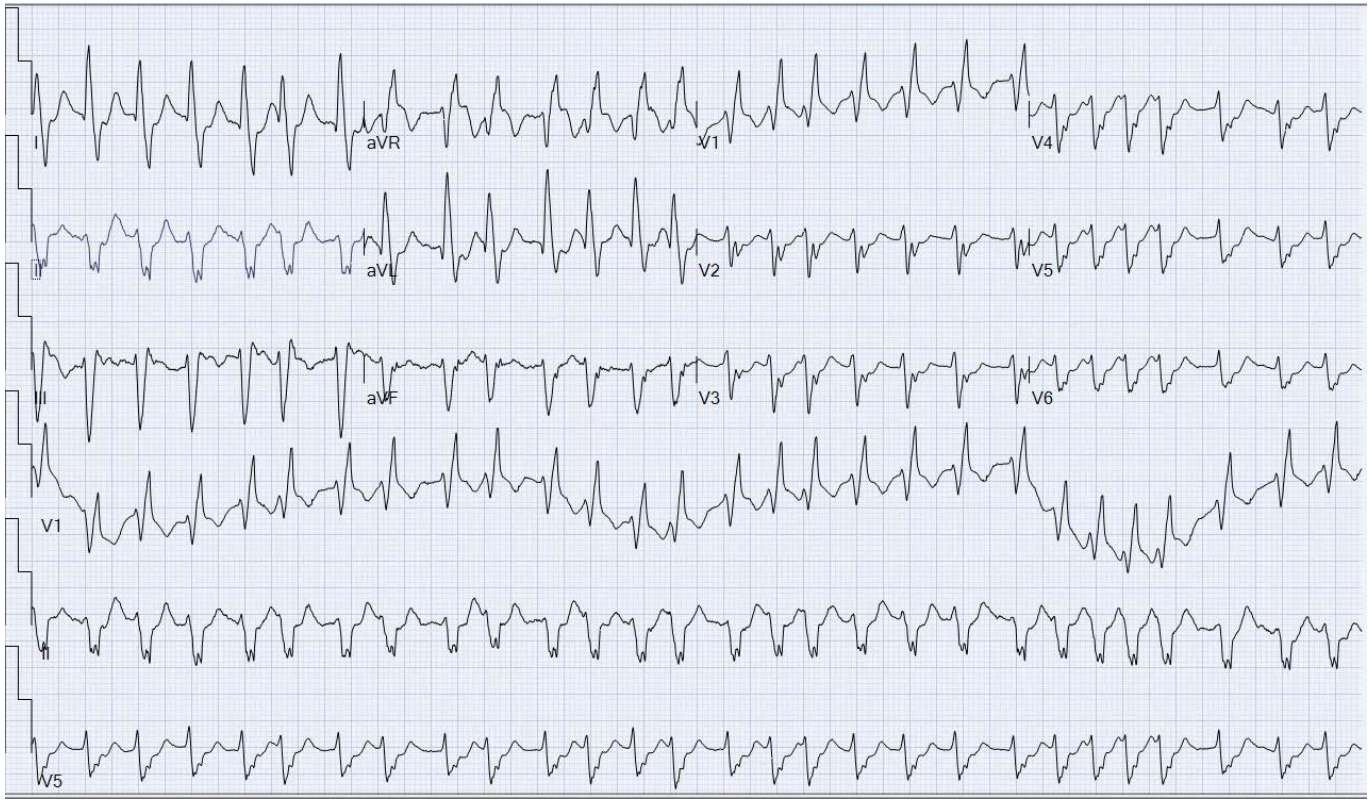
- Common ECG Missteps
  - Old infarct
  - Heart blocks
  - Wide complex tachycardia
  - ST elevation

- Common Telemetry Missteps
  - Artifact
  - Inaccurate HR

What is the rhythm ?

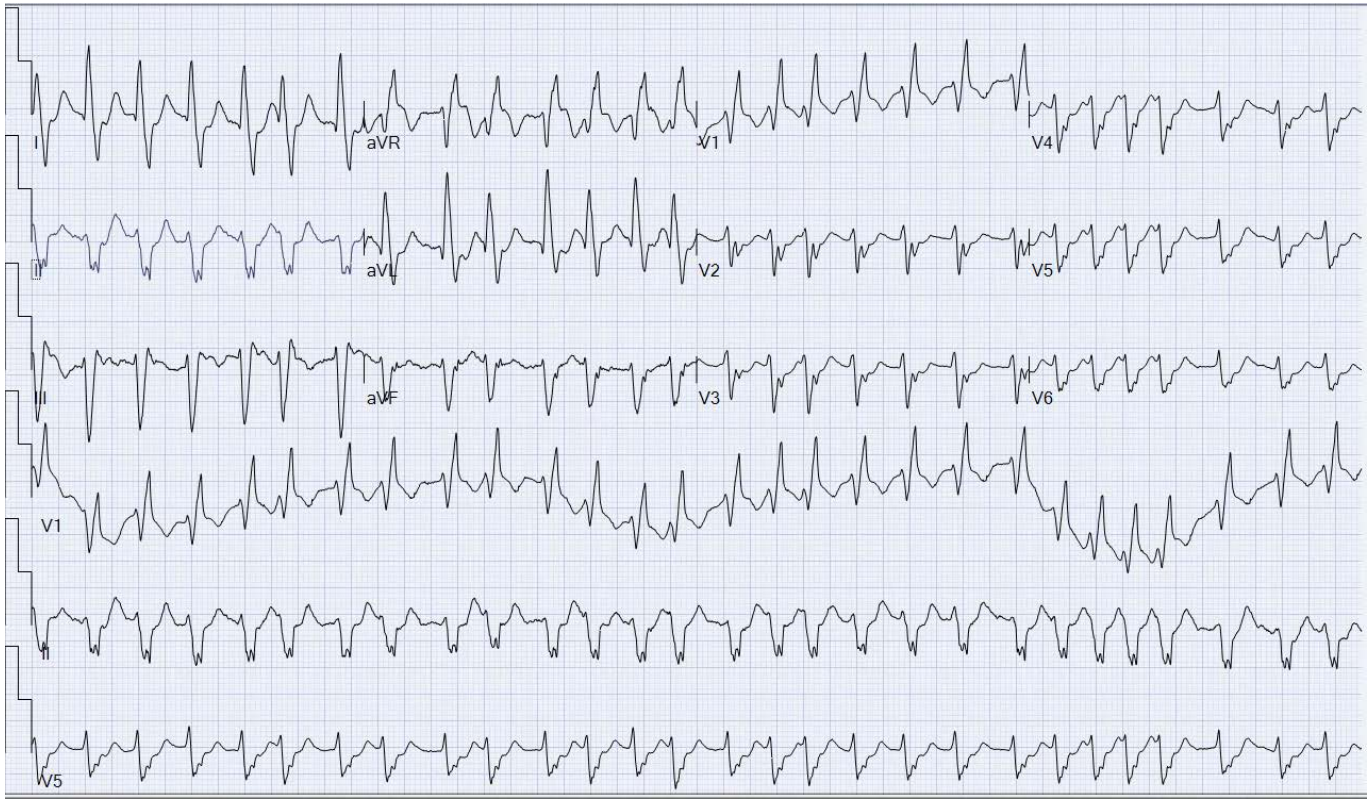


What is the rhythm ?



1. Ventricular Tachycardia
2. Atrial fibrillation with aberrant conduction
3. Ventricular Fibrillation
4. Don’t know . Call STAT EP consult

What is this ?



1. Ventricular Tachycardia
2. Atrial fibrillation with aberrant conduction
3. Ventricular Fibrillation
4. Don’t know . Call STAT EP consult

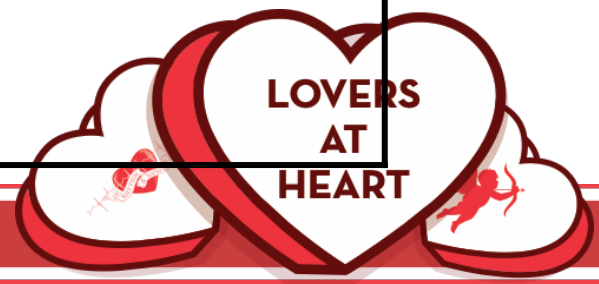
Wide complex tachycardia

Common scenarios

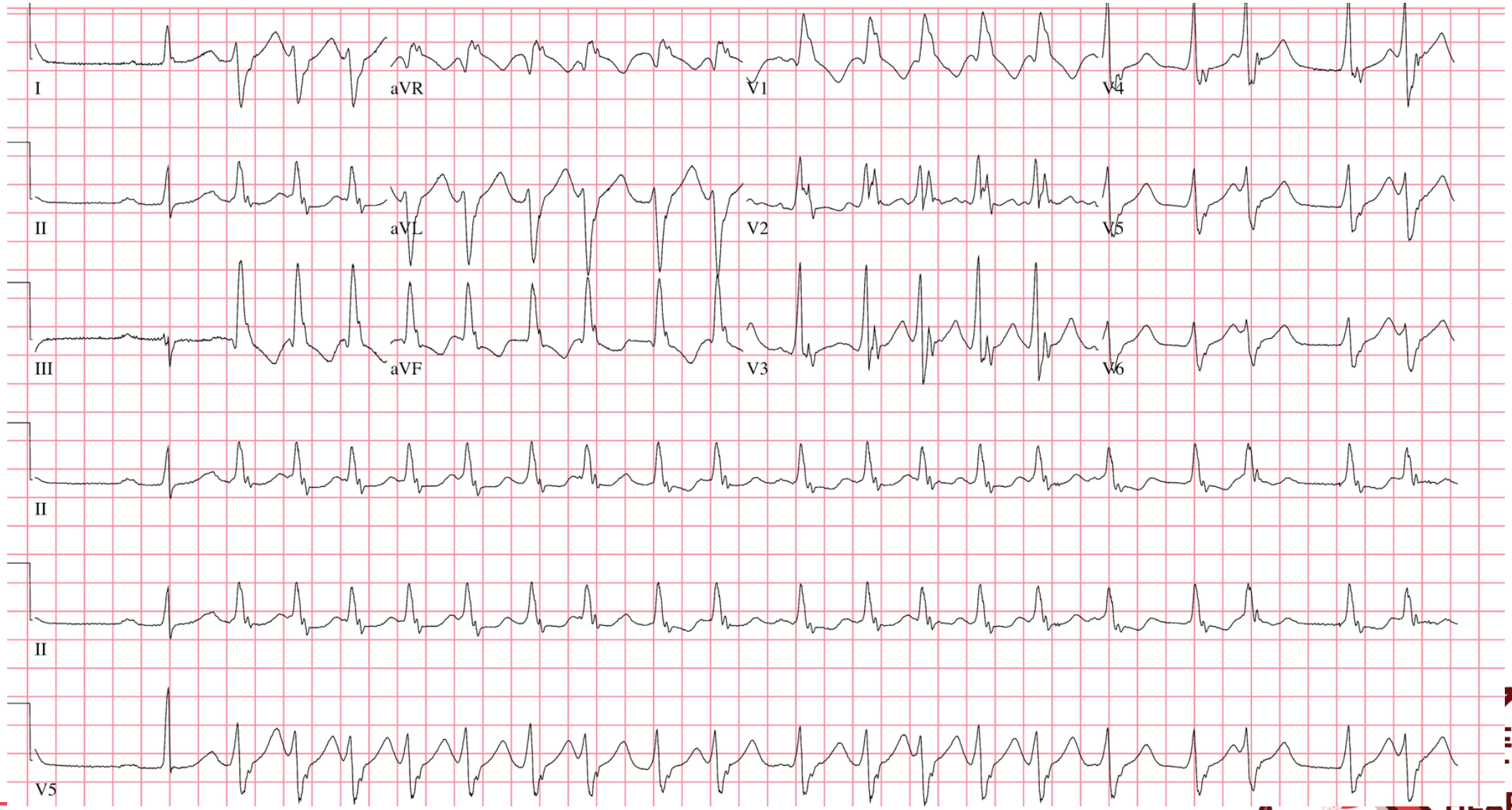
- Ventricular tachycardia
- Supra ventricular tachycardia or Atrial fibrillation with aberrant conduction
- SVT with conduction over accessory pathway

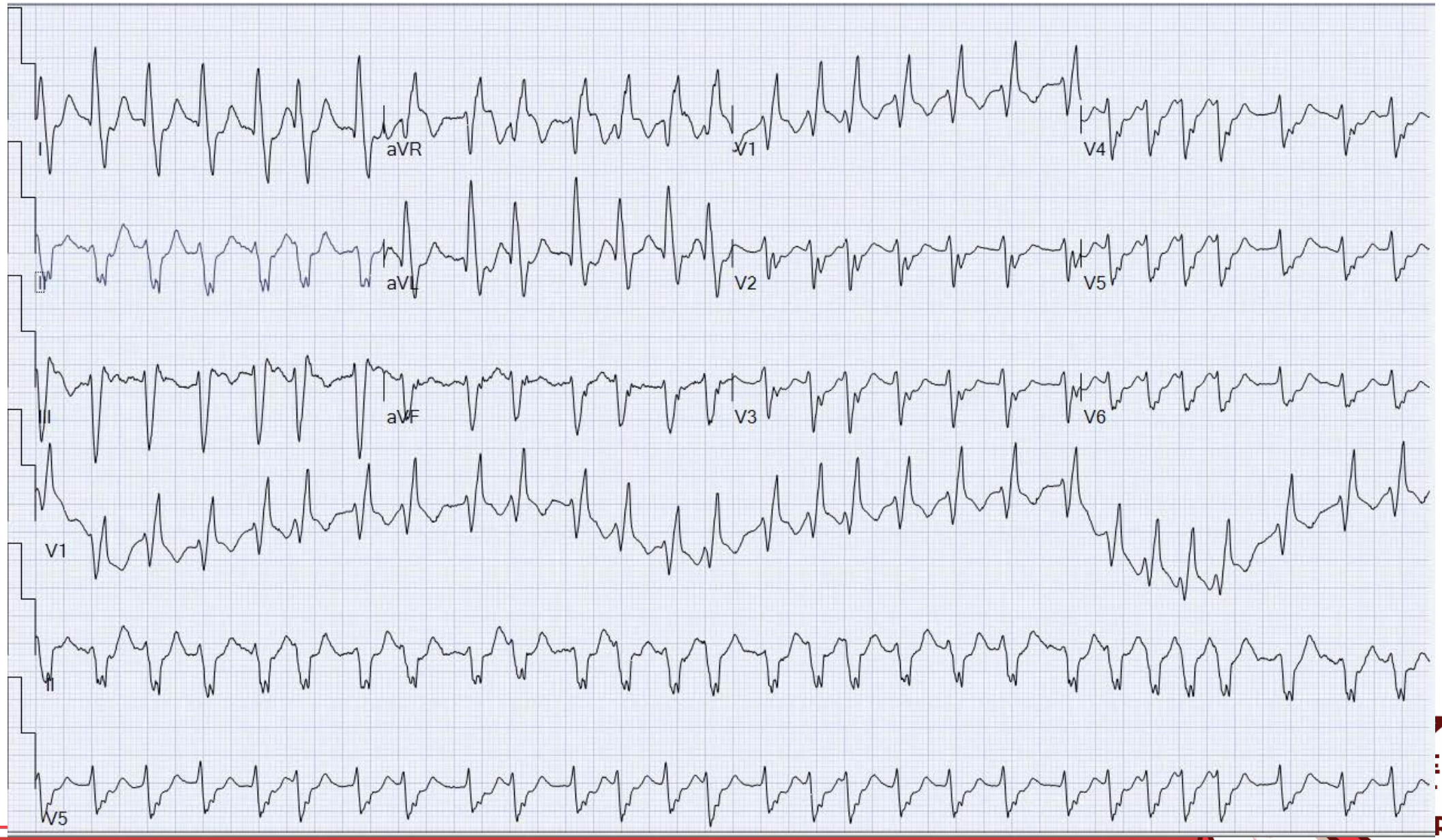
Differential Diagnosis of Tachycardia

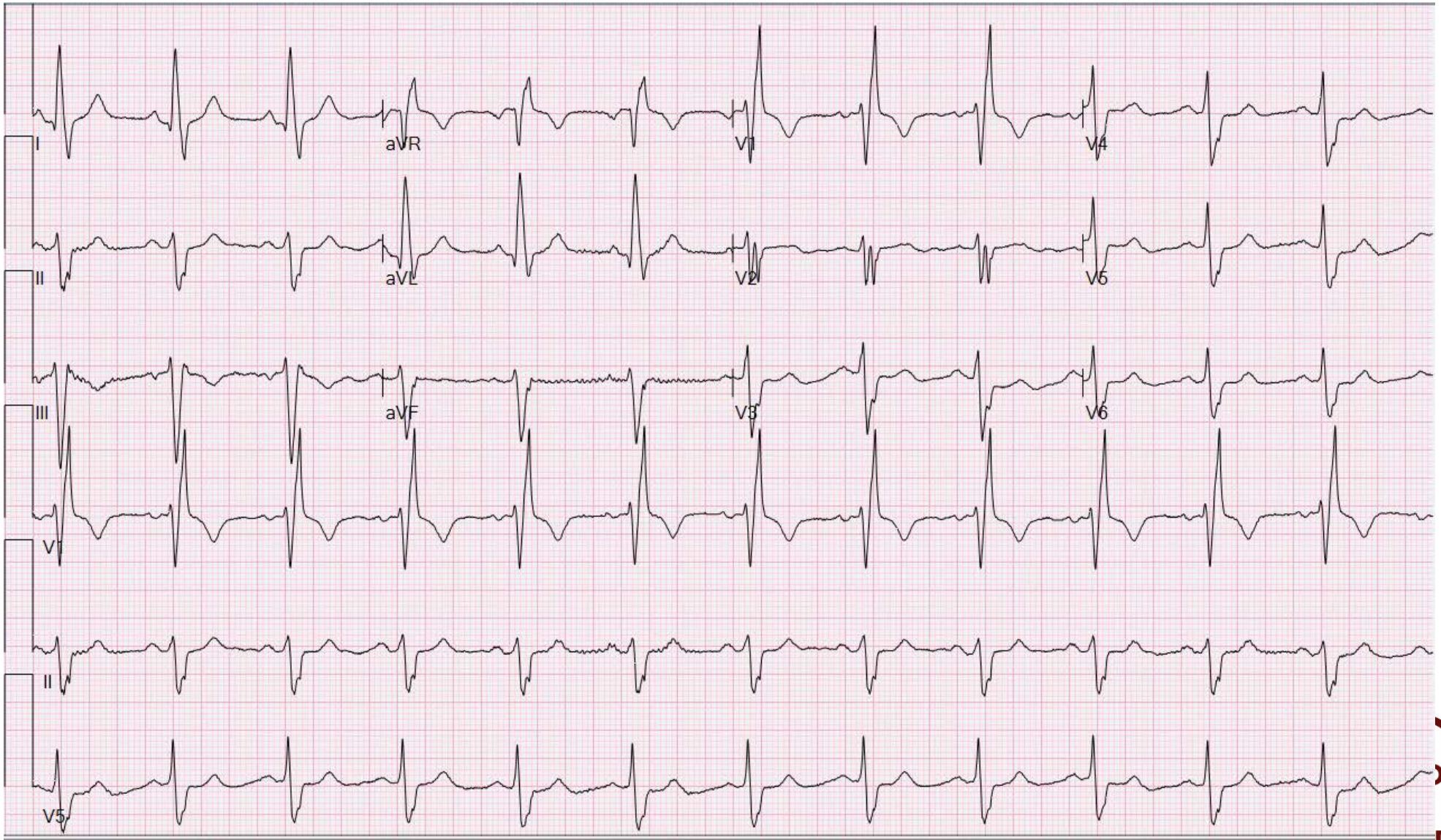
Tachycardia	Narrow Complex	Wide Complex
Regular	ST SVT Atrial flutter	ST w/ aberrancy SVT w/ aberrancy VT
Irregular	A-fib A-flutter w/ variable conduction MAT	A-fib w/ aberrancy A-fib w/ WPW VT



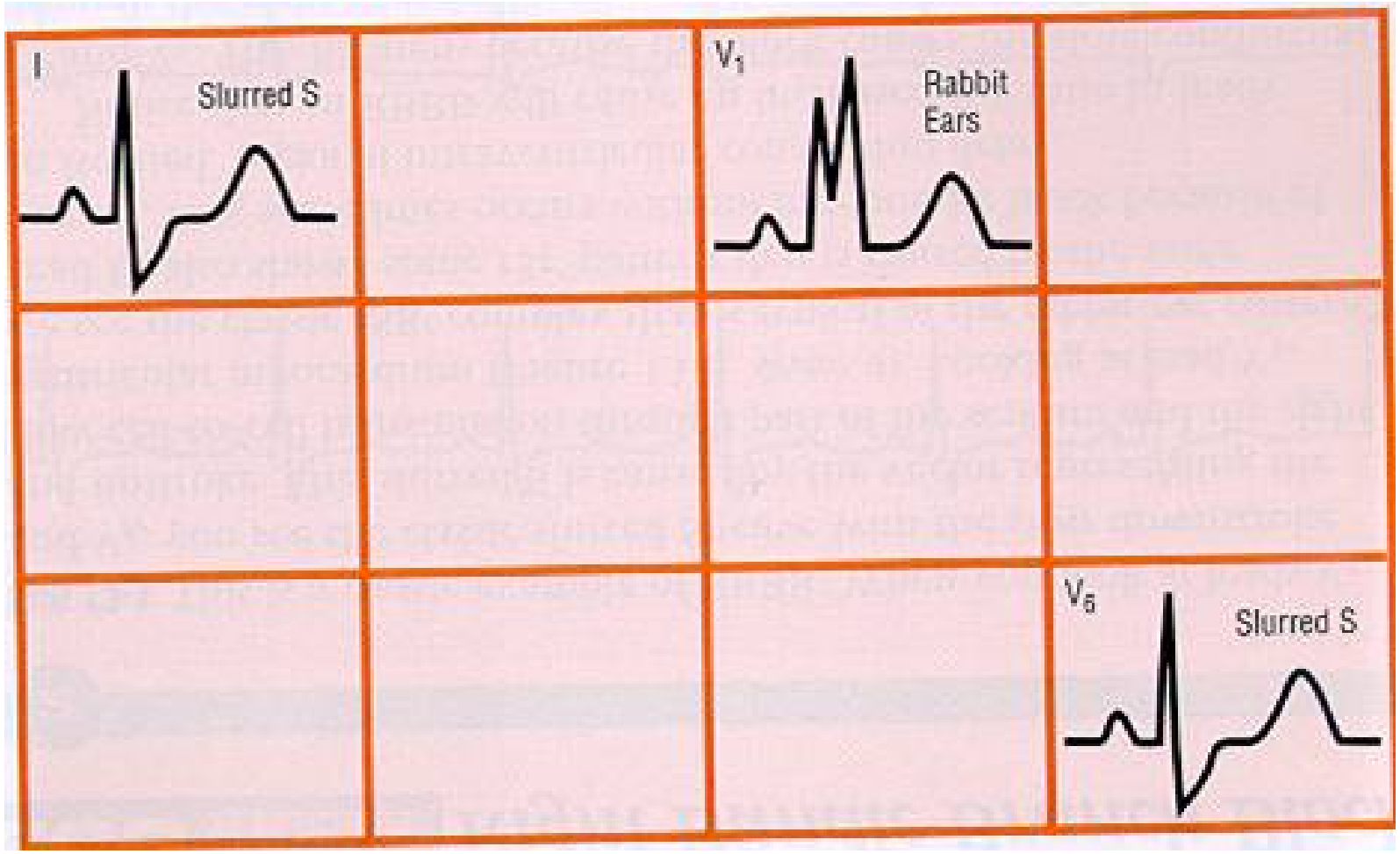
AF with aberrant conduction



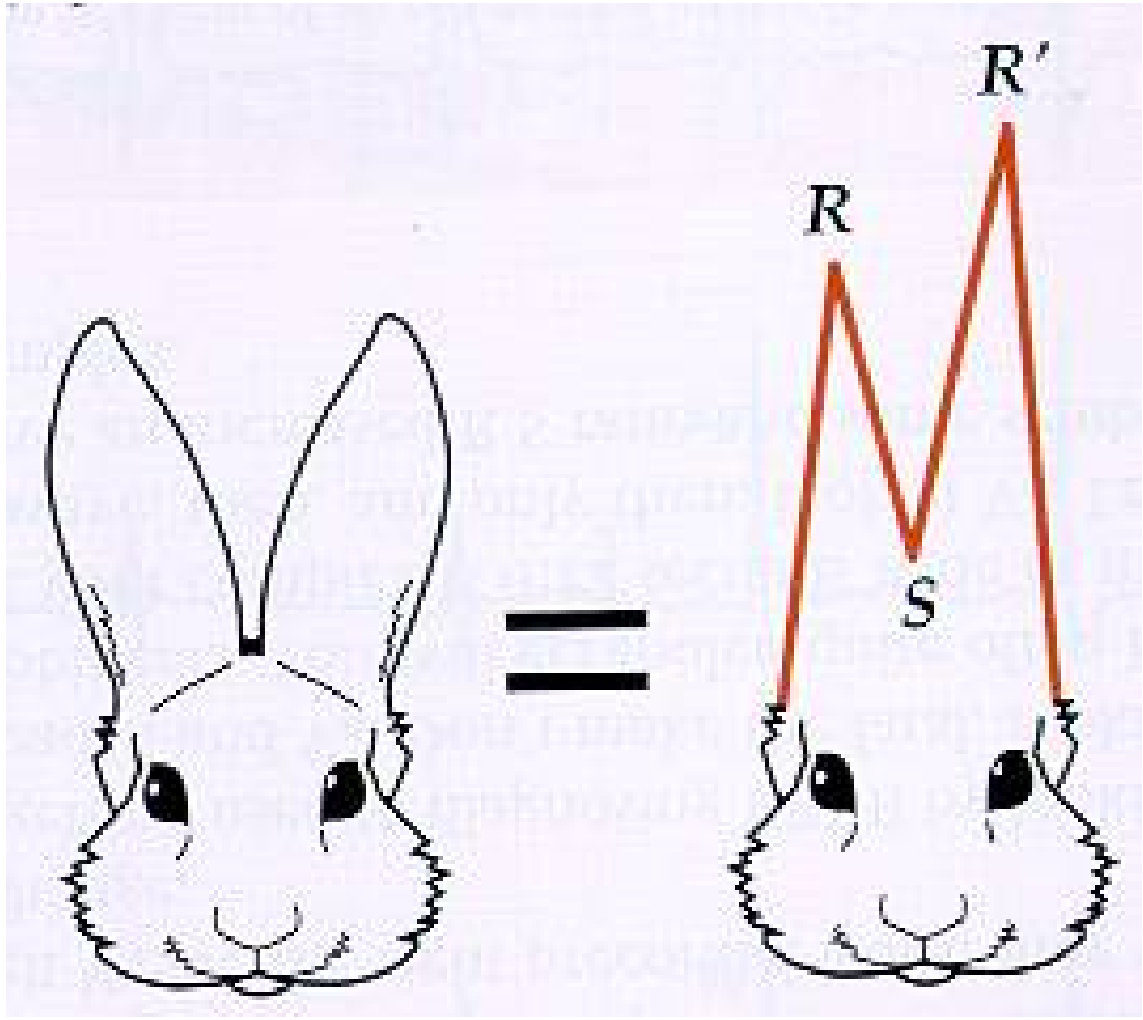

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V
II
V5

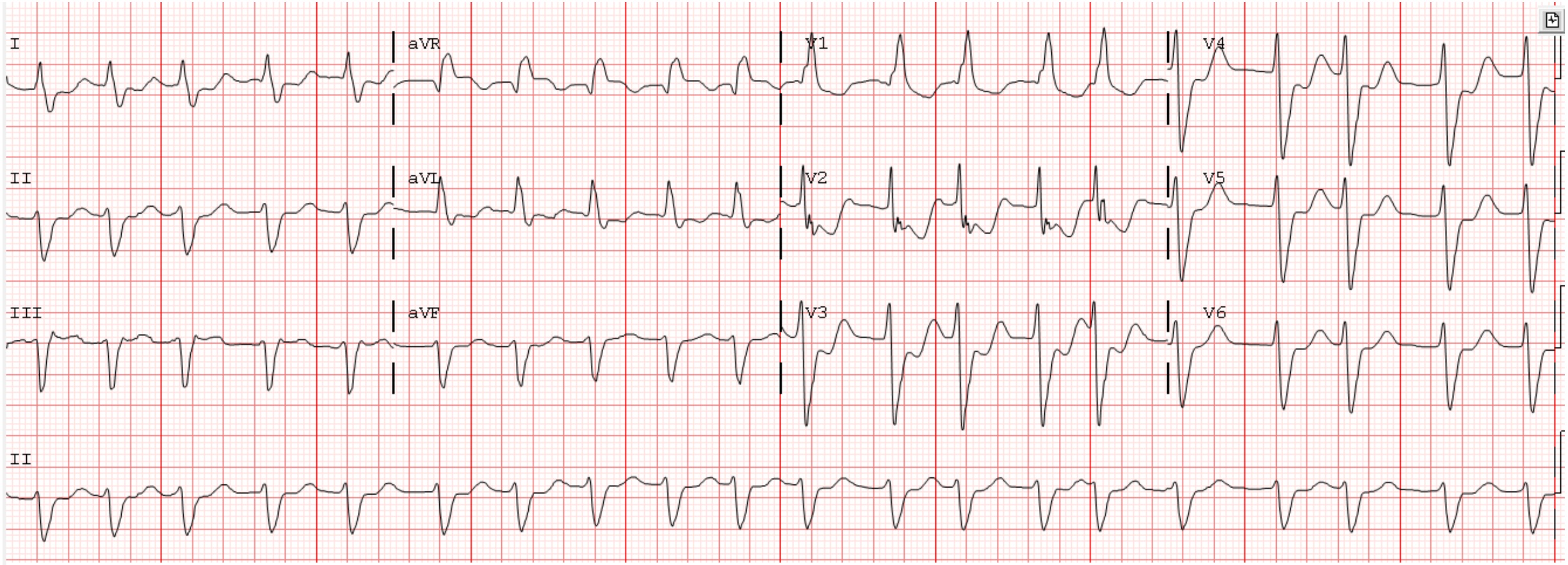
Right Bundle Branch Block



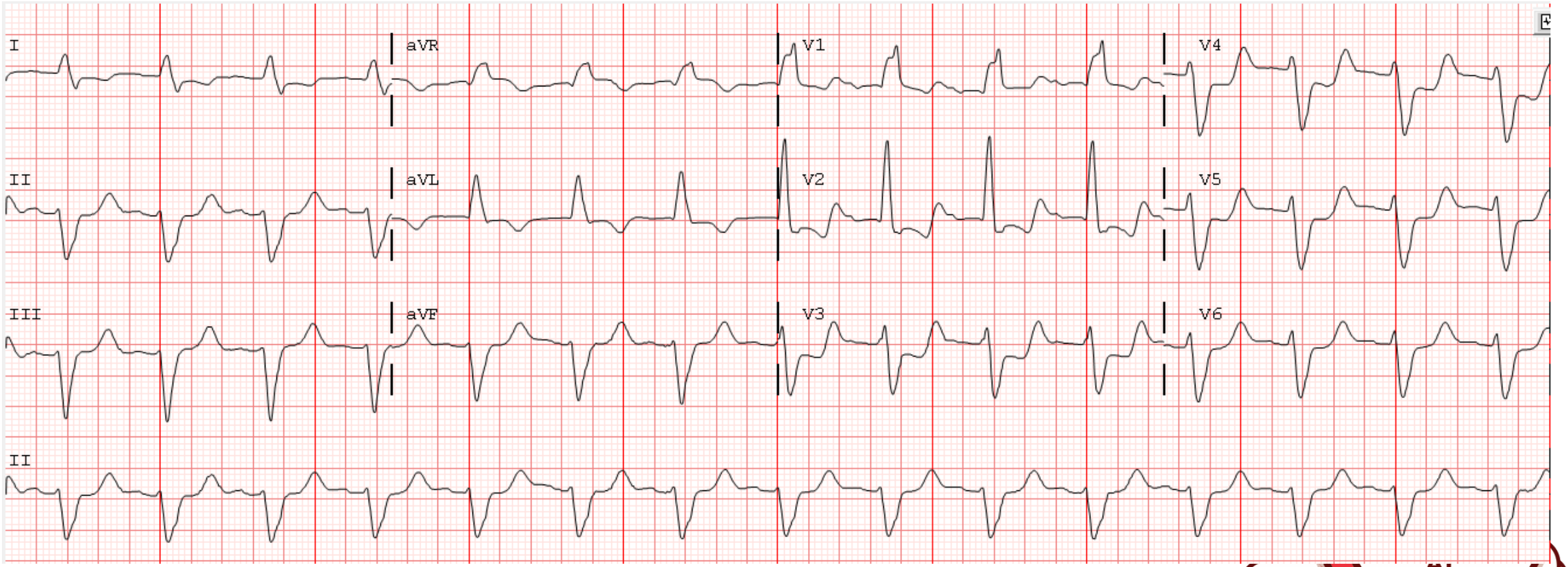
Right Bundle Branch Block



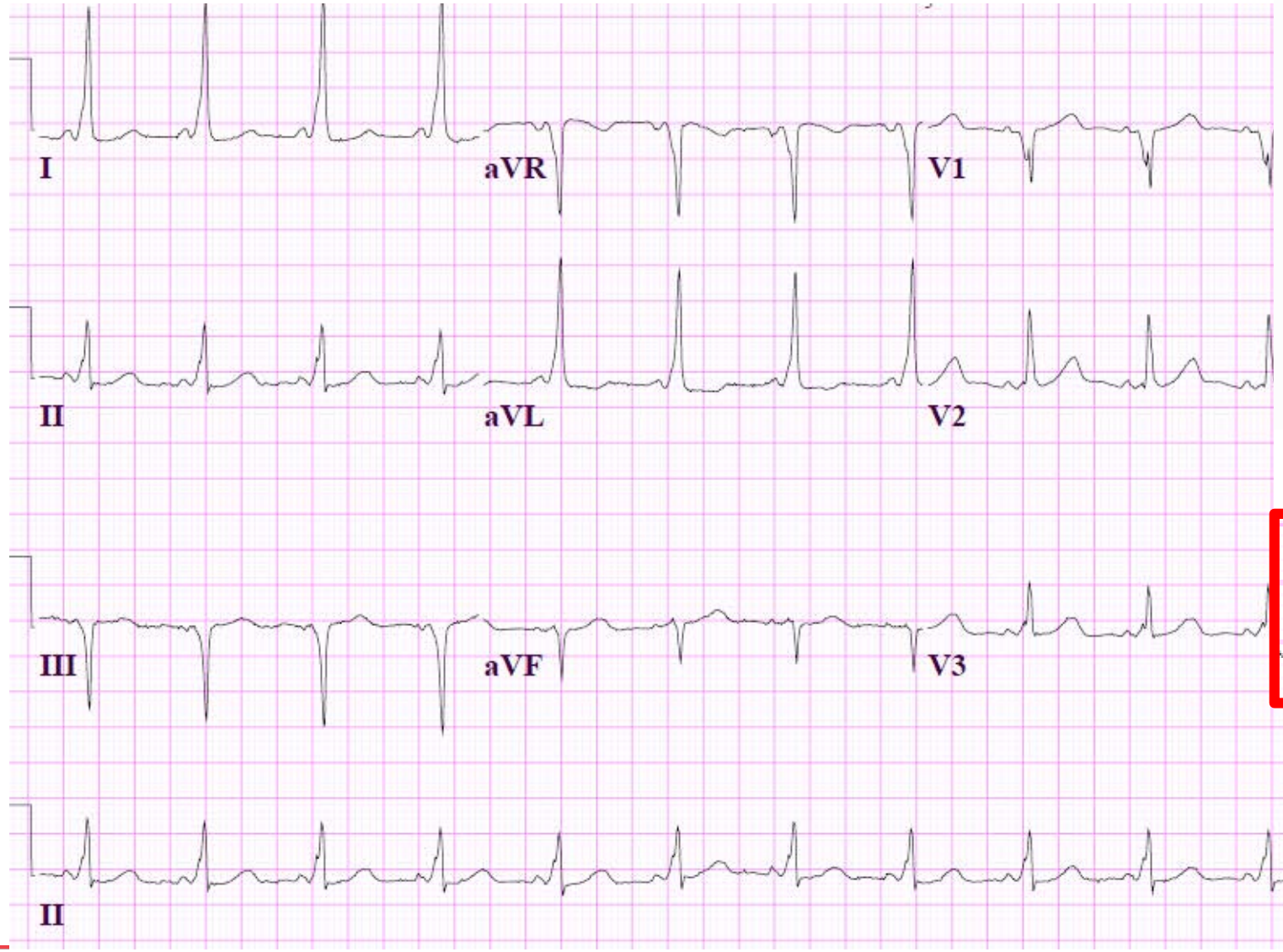
Afib with RBBB and LAFB

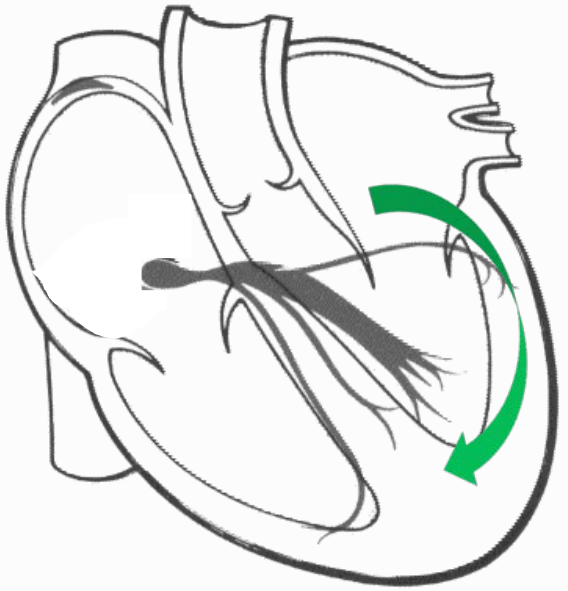


Baseline

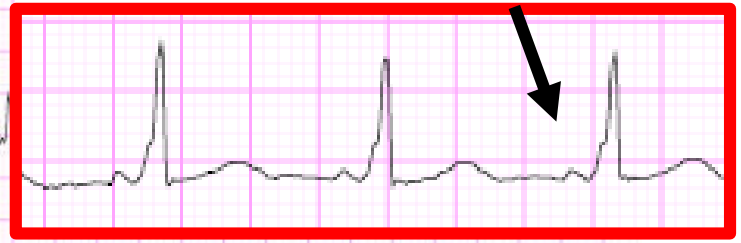


Wolff-Parkinson-White Syndrome

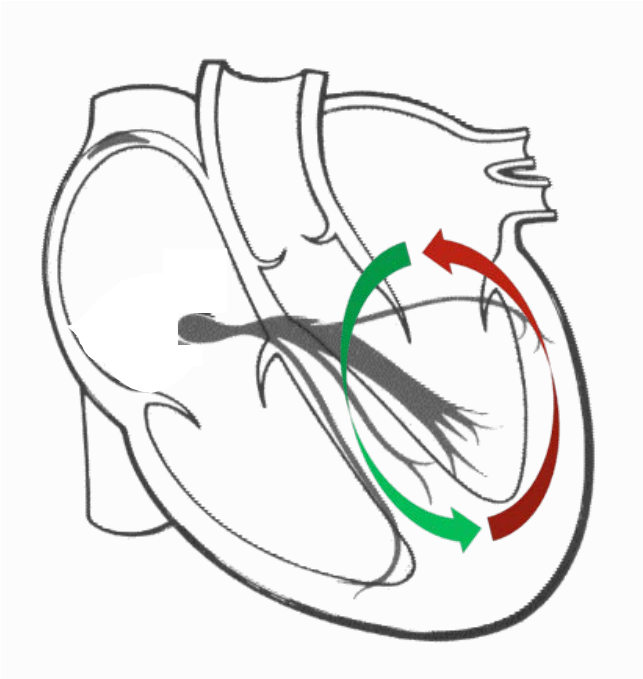




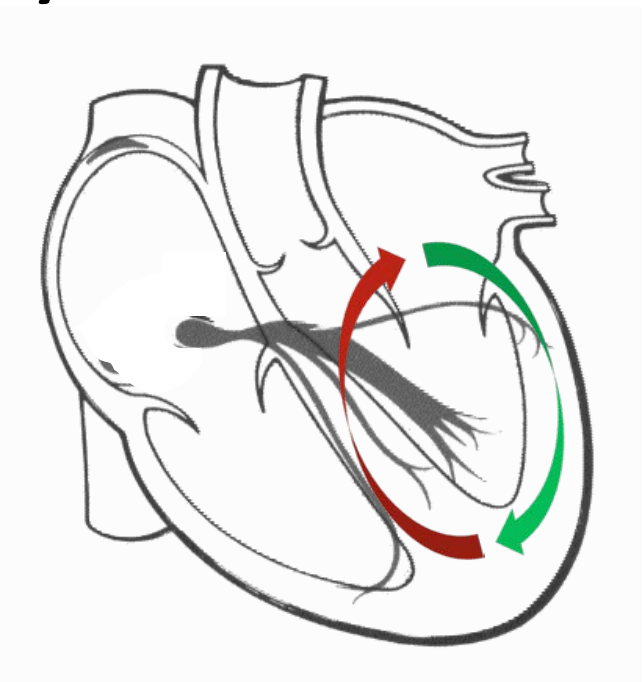
Delta Wave



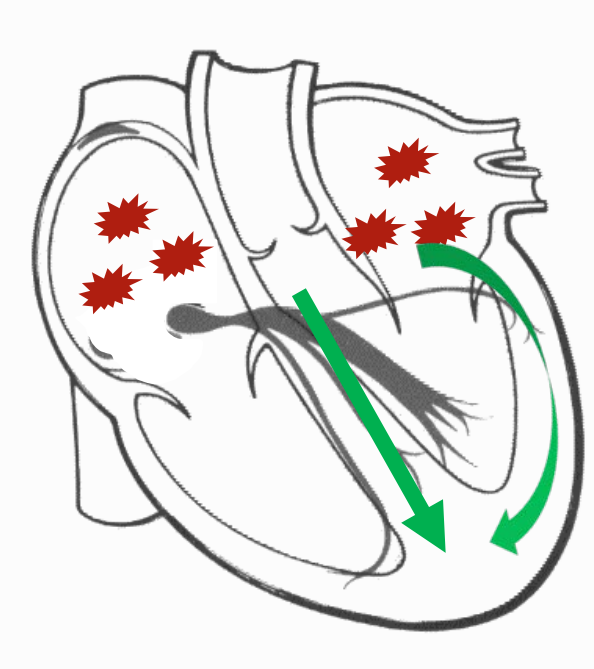
WPW Arrhythmia Mechanisms



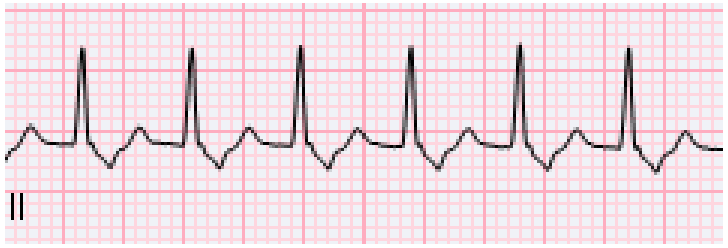
Orthodromic



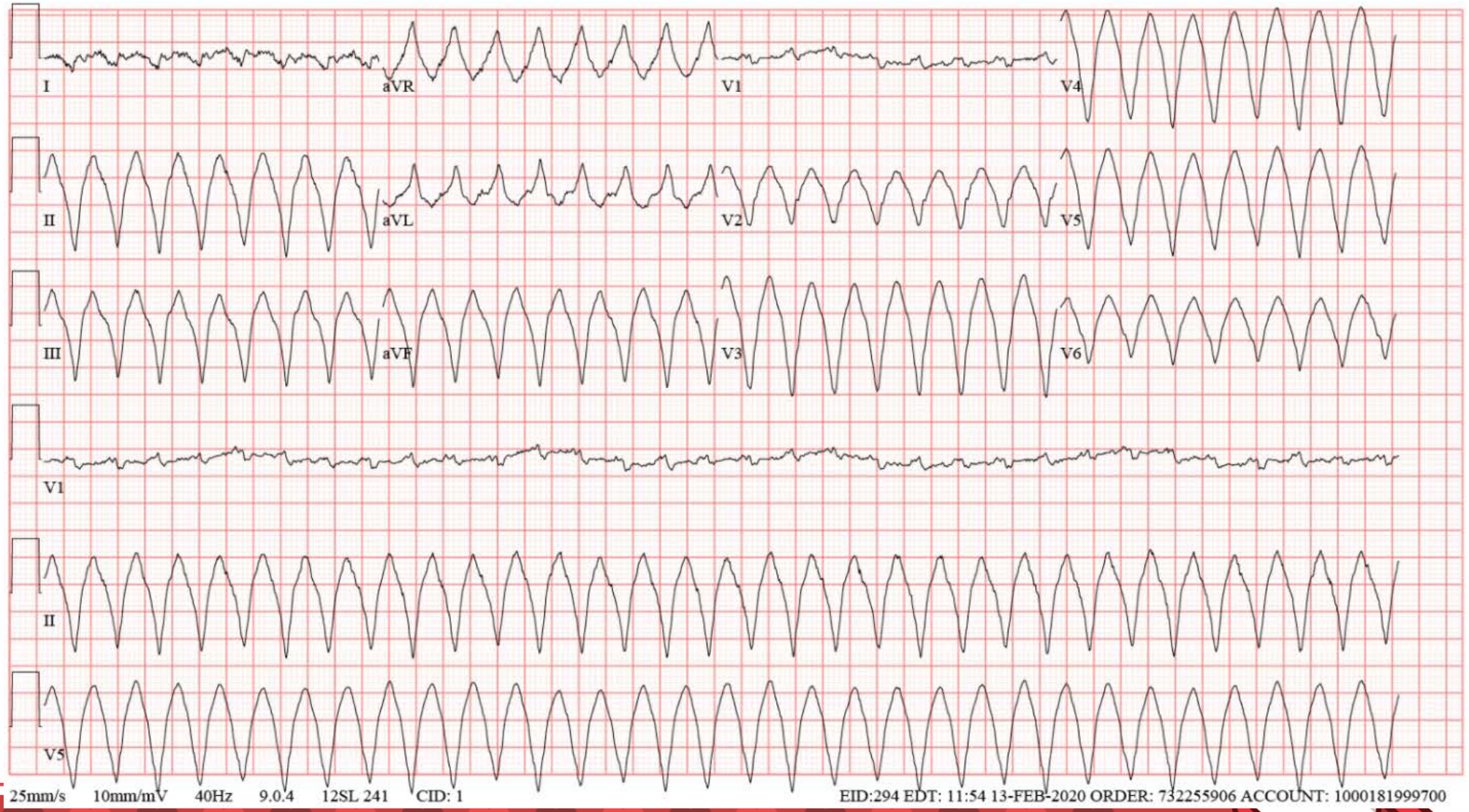
Antidromic



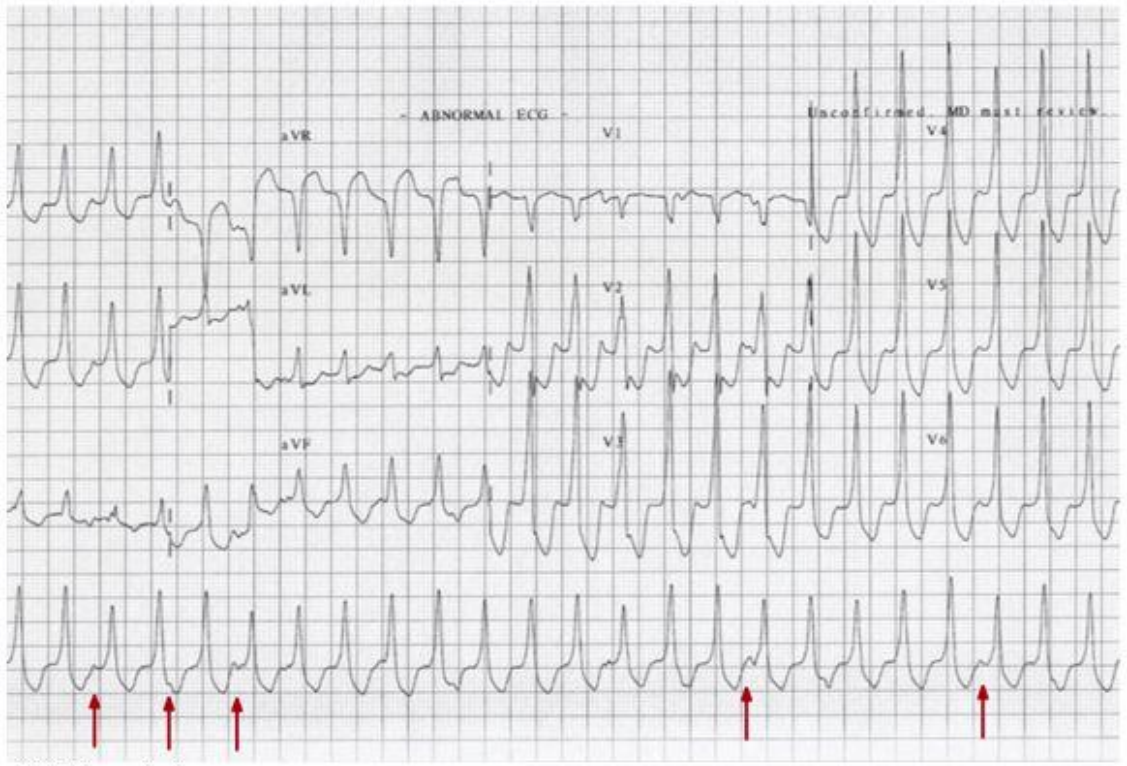
Atrial Fibrillation



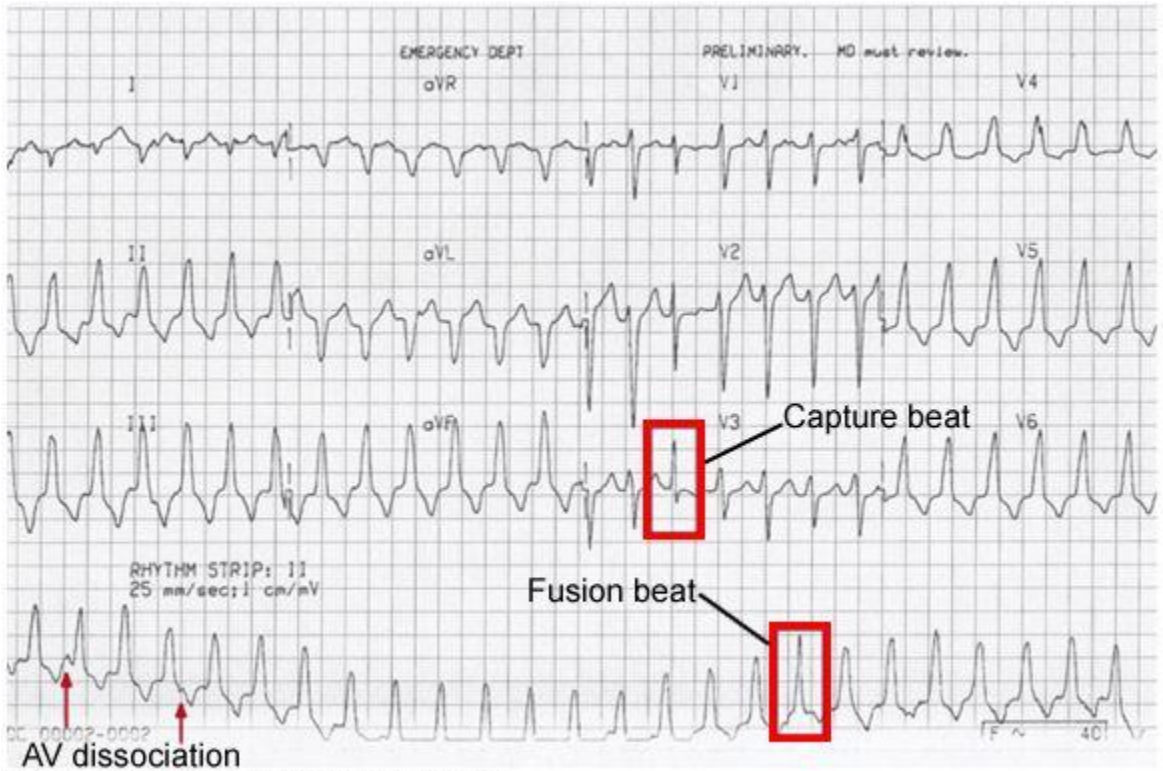
Ventricular Tachycardia



Monomorphic VT



AV Dissociation



Fusion/Capture Beats/AV Dissociation

AV dissociation , fusion beats and capture beats.

Outline

- ECG Basics

- Common ECG Missteps
  - Old infarct
  - Heart blocks
  - Wide complex tachycardia
  - ST elevation on ECG

- Common Telemetry Missteps
  - Artifact
  - Inaccurate HR

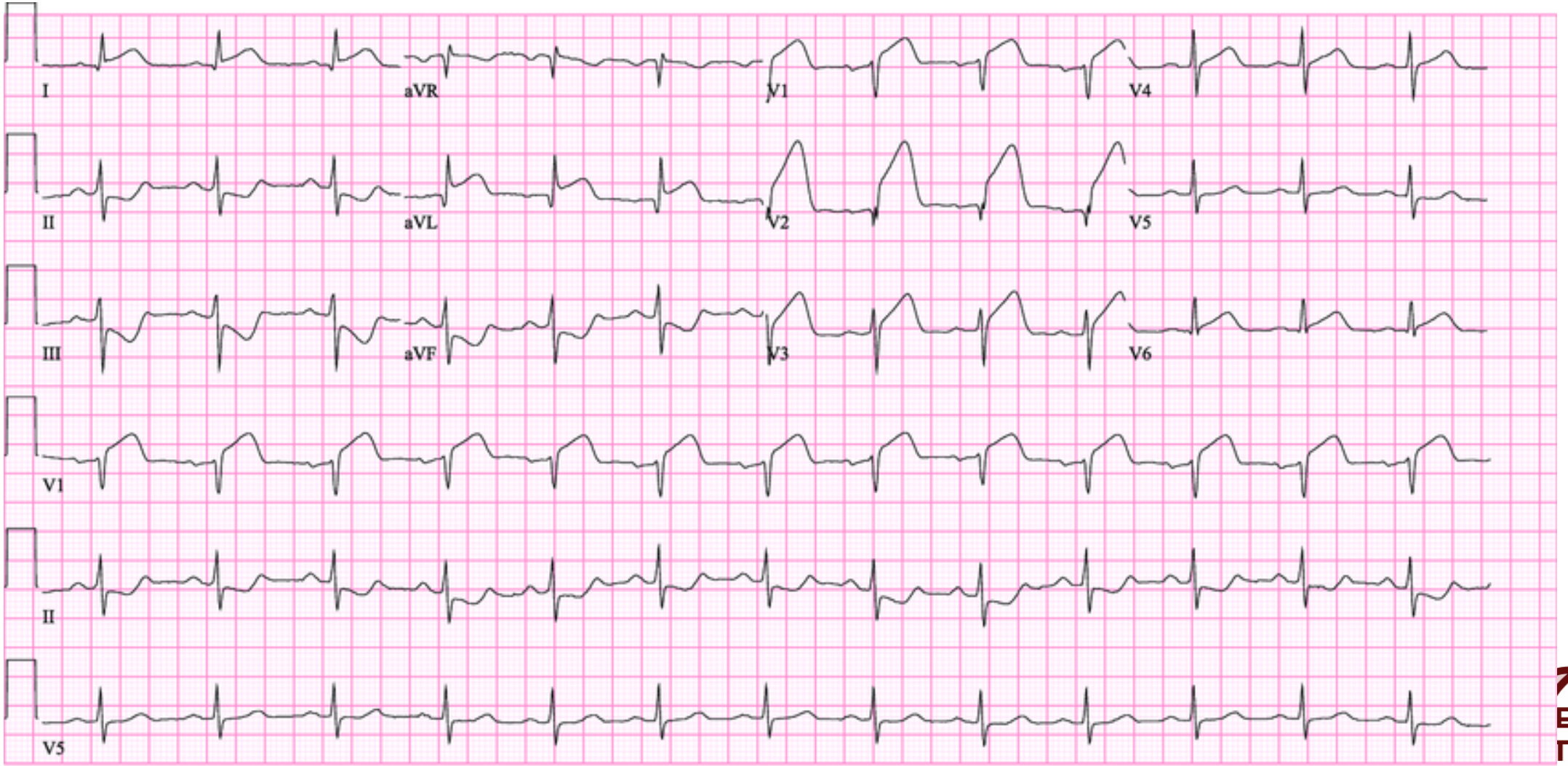
ST elevation

Think

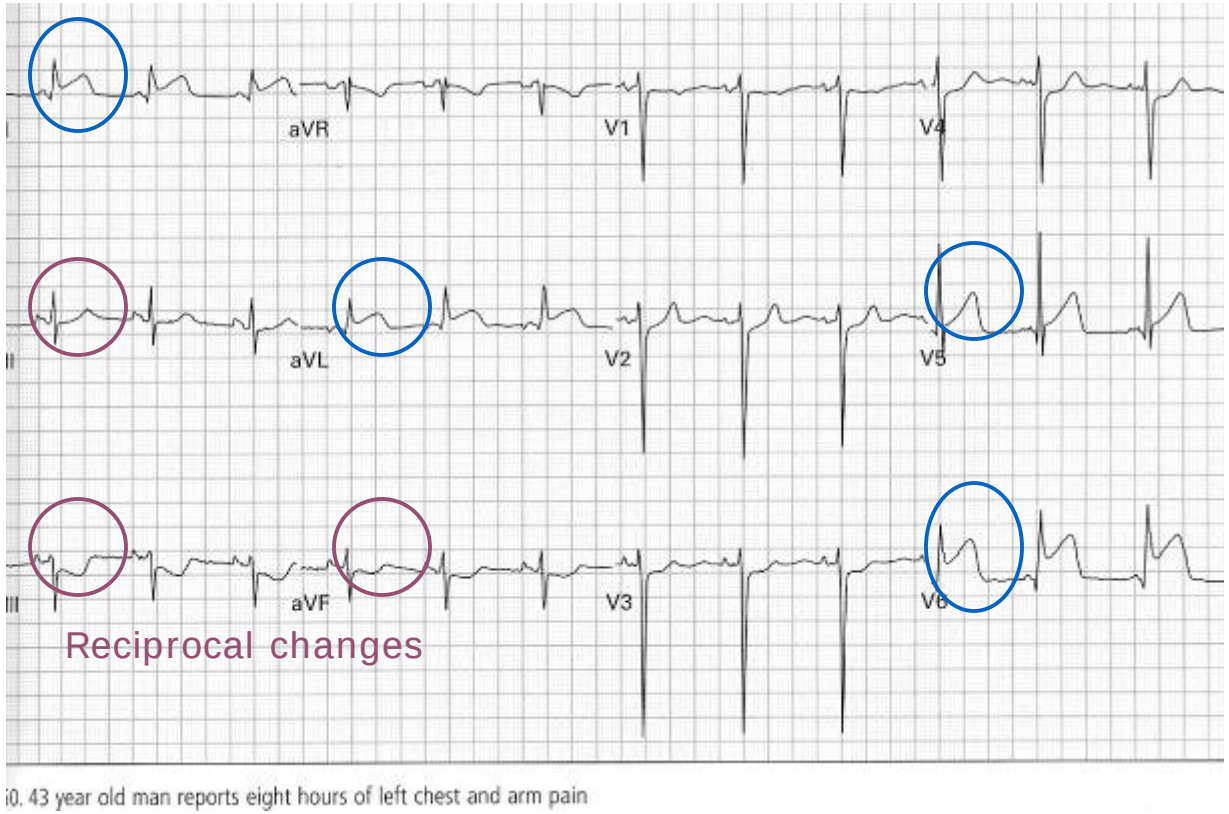
- Acute MI
- Pericarditis
- Early repolarization

Not all ST elevations are Acute MI/STEMI

Acute MI-LAD Occlusion

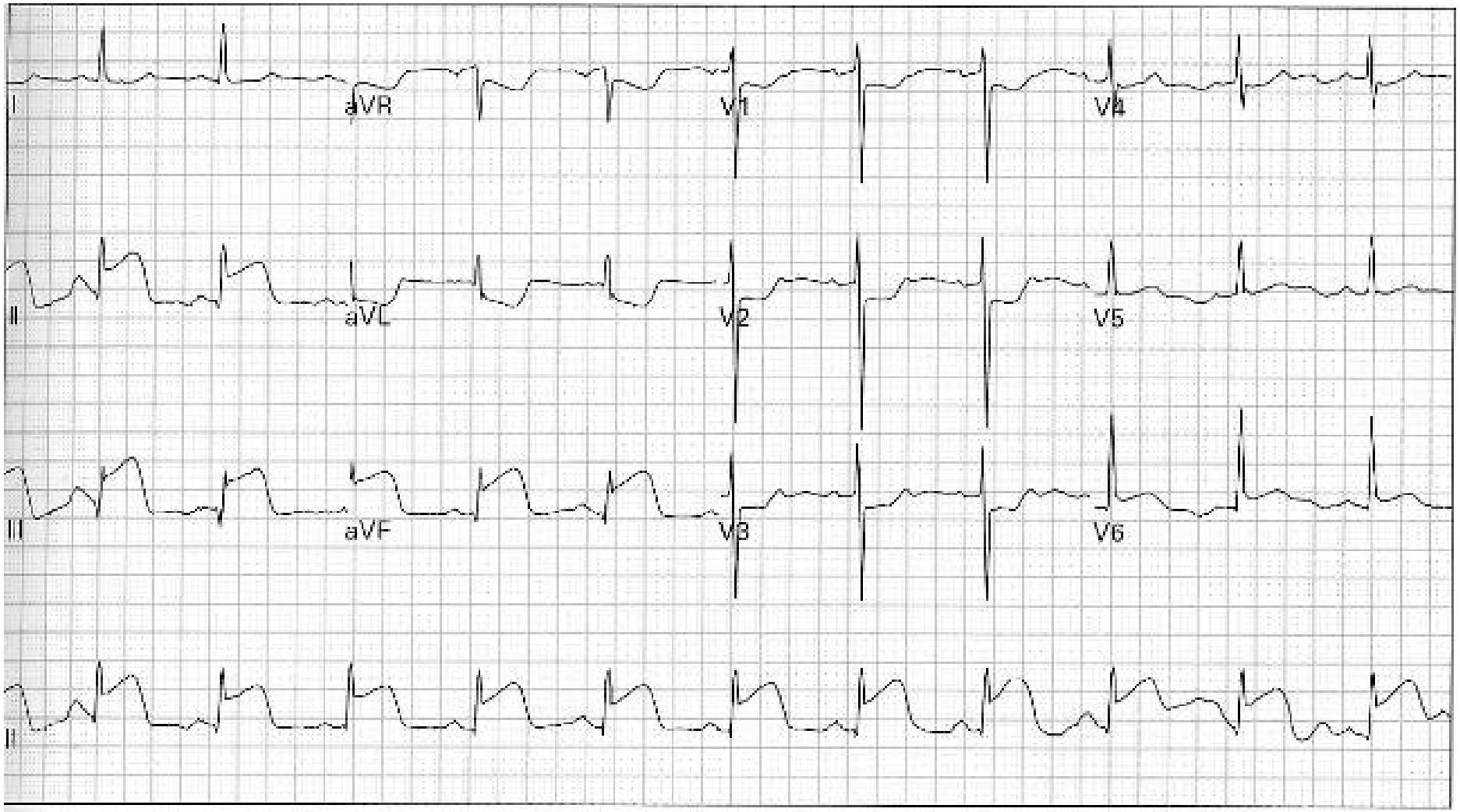


Lateral MI



50, 43 year old man reports eight hours of left chest and arm pain

Inferolateral MI



37. 38 year old man with chest pain, nausea, and diaphoresis

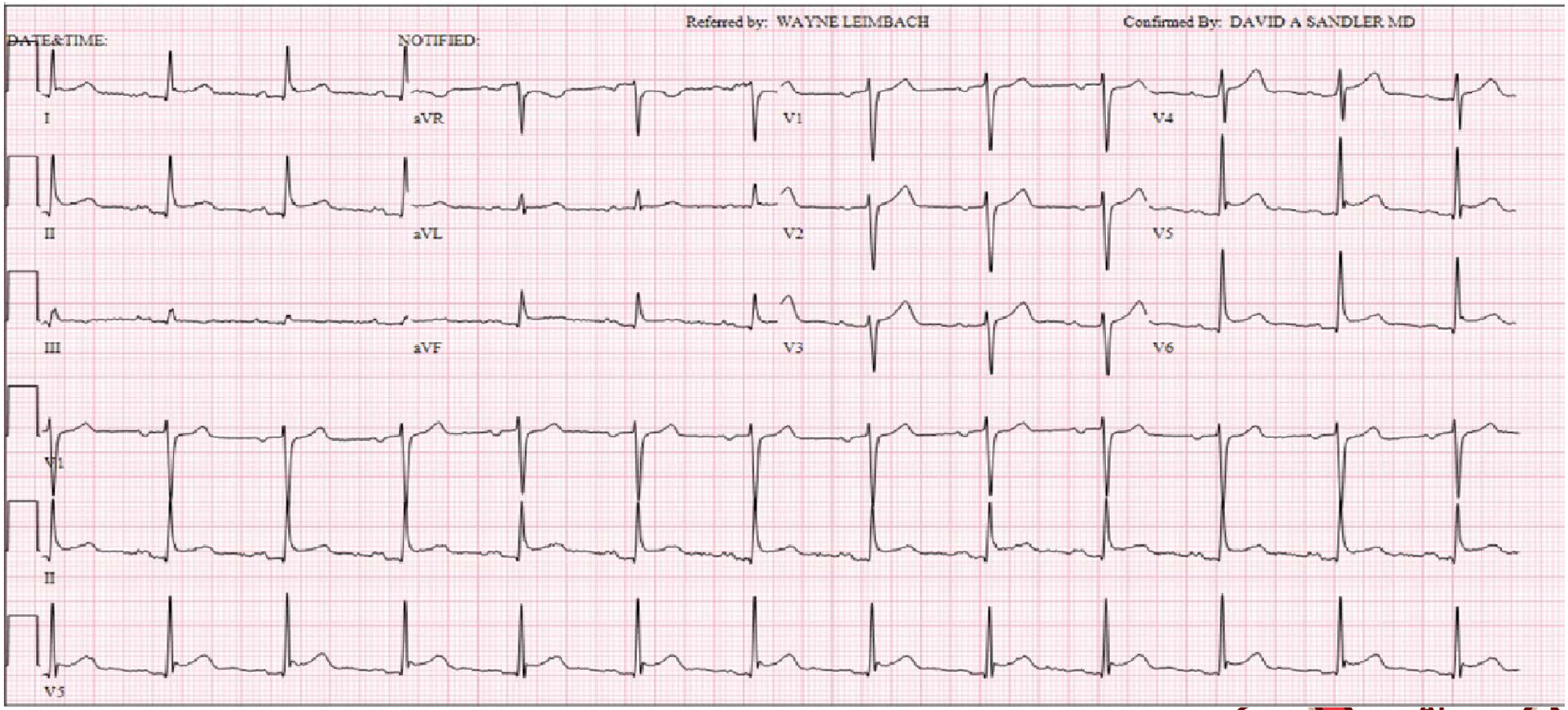
ST elevation II, III, aVF

ST depression in aVL, V1-V3 are reciprocal changes

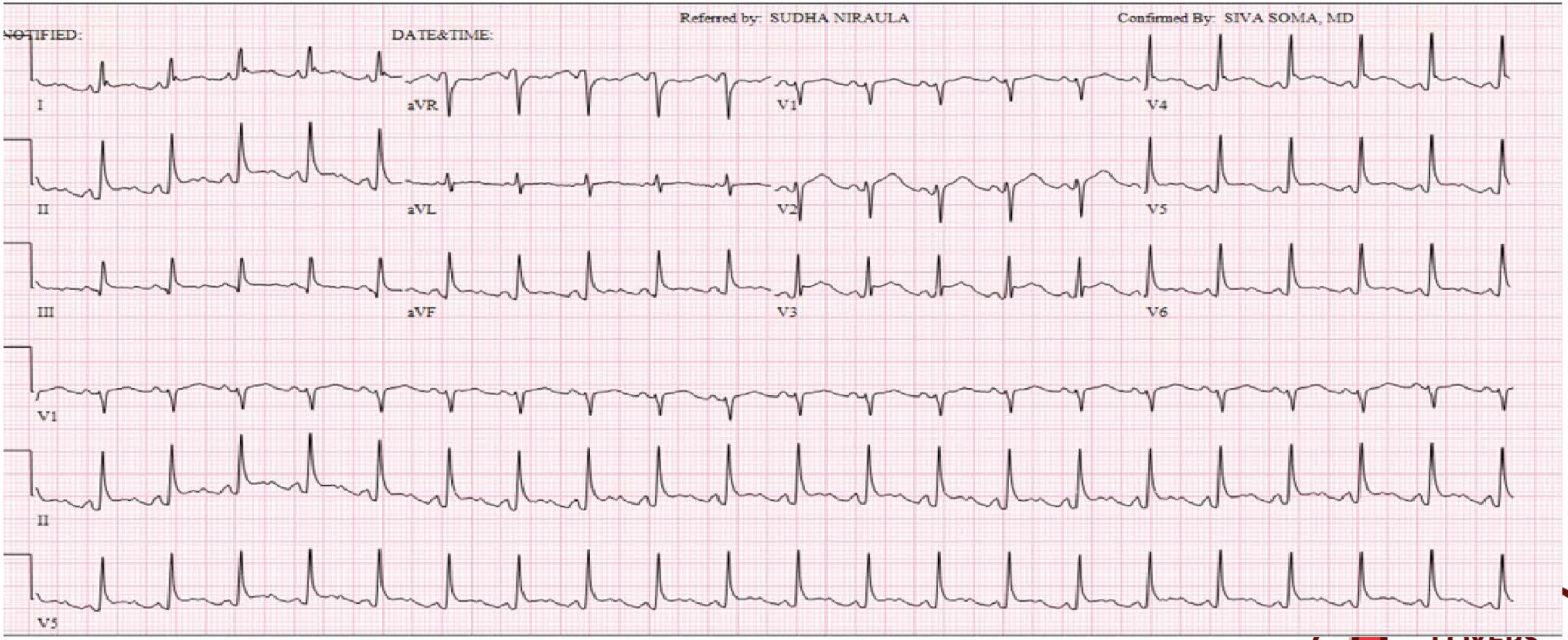
Pericarditis

- Diffuse ST elevation
- No reciprocal changes
- PR depression
- Clinical scenario

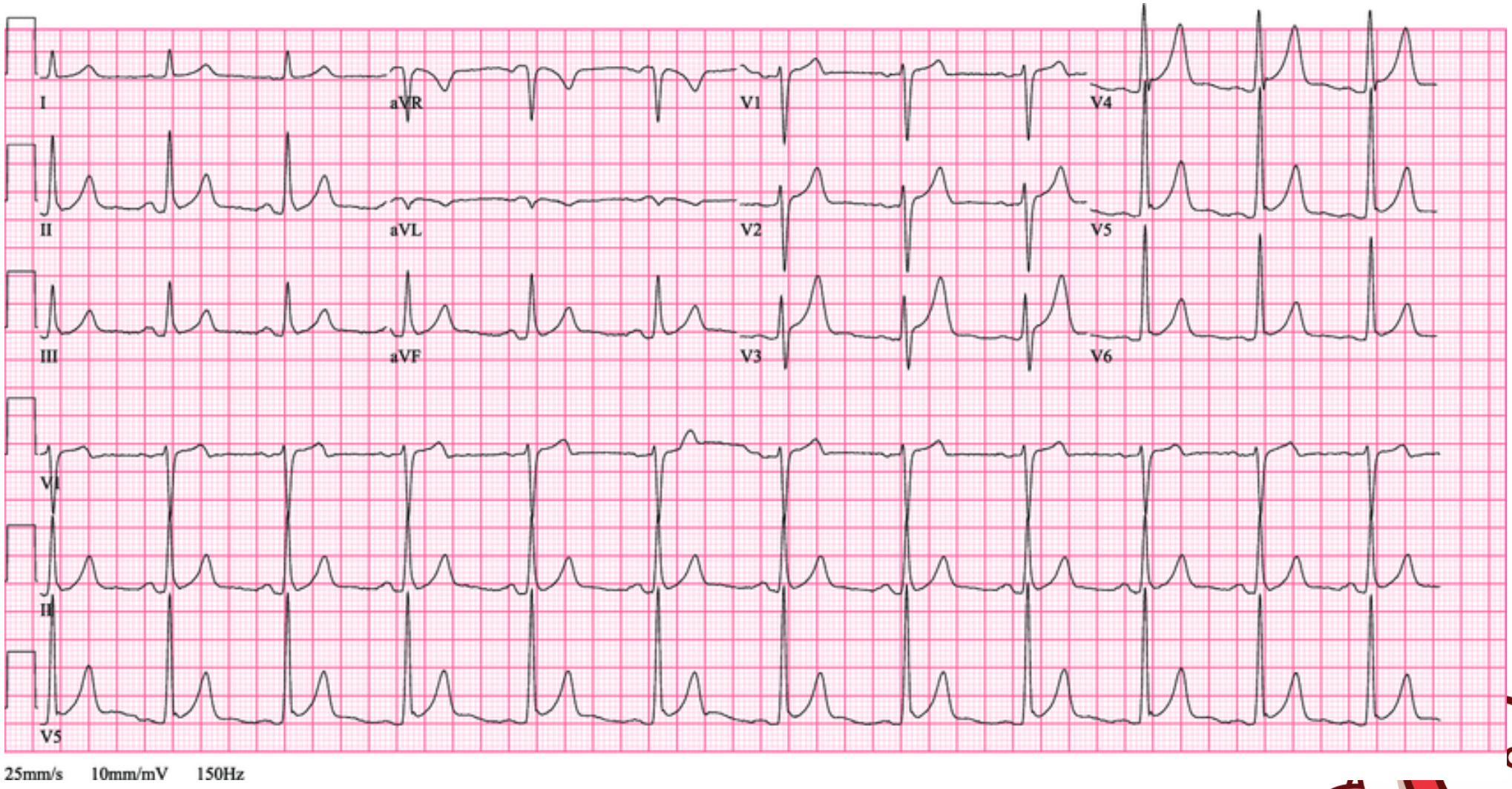
Acute pericarditis

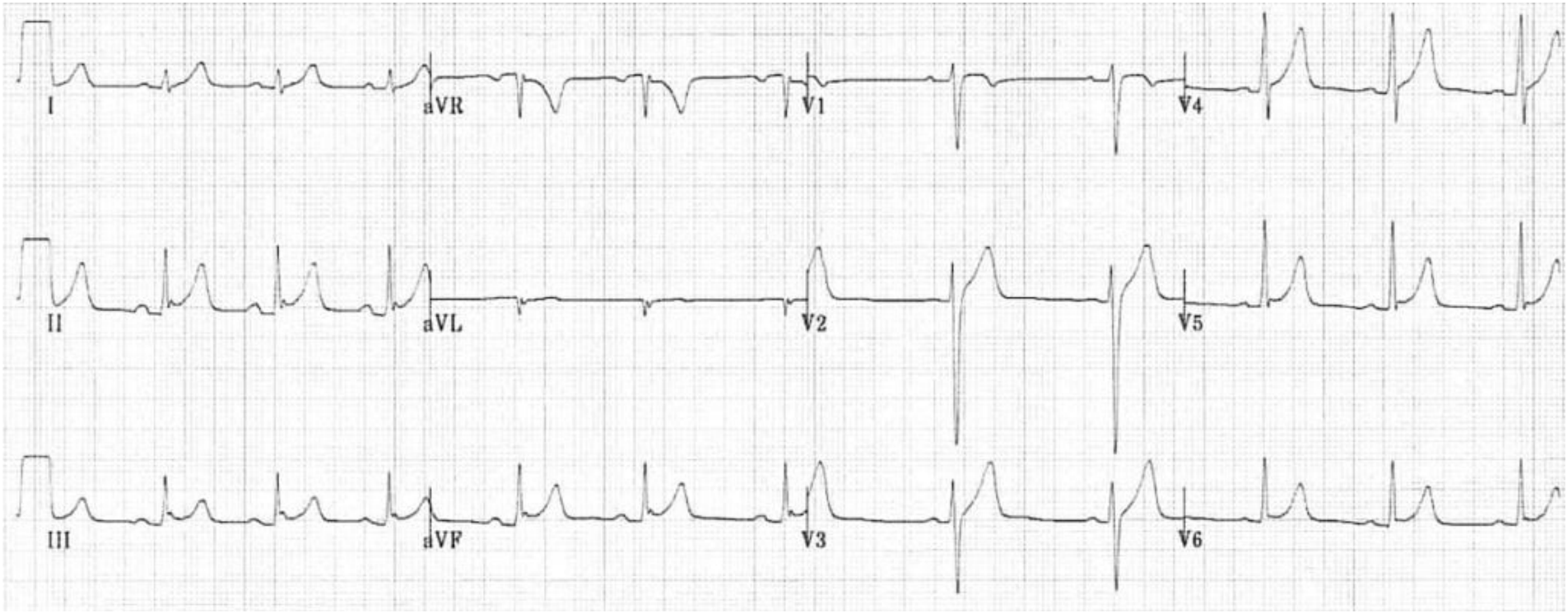


Acute pericarditis



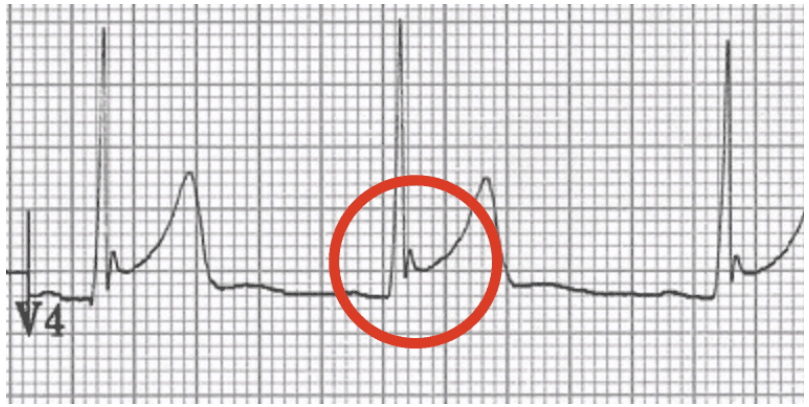
Early repolarization





•There is generalized concave ST elevation in the precordial (V2-6) and limb leads (I, II, III, aVF).
•J-point notching is evident in the inferior leads (II, III and aVF).
•There are prominent, slightly asymmetrical T waves that are concordant with the main vector of the QRS complexes

upward concavity or
ST coving



J-point notching

Outline

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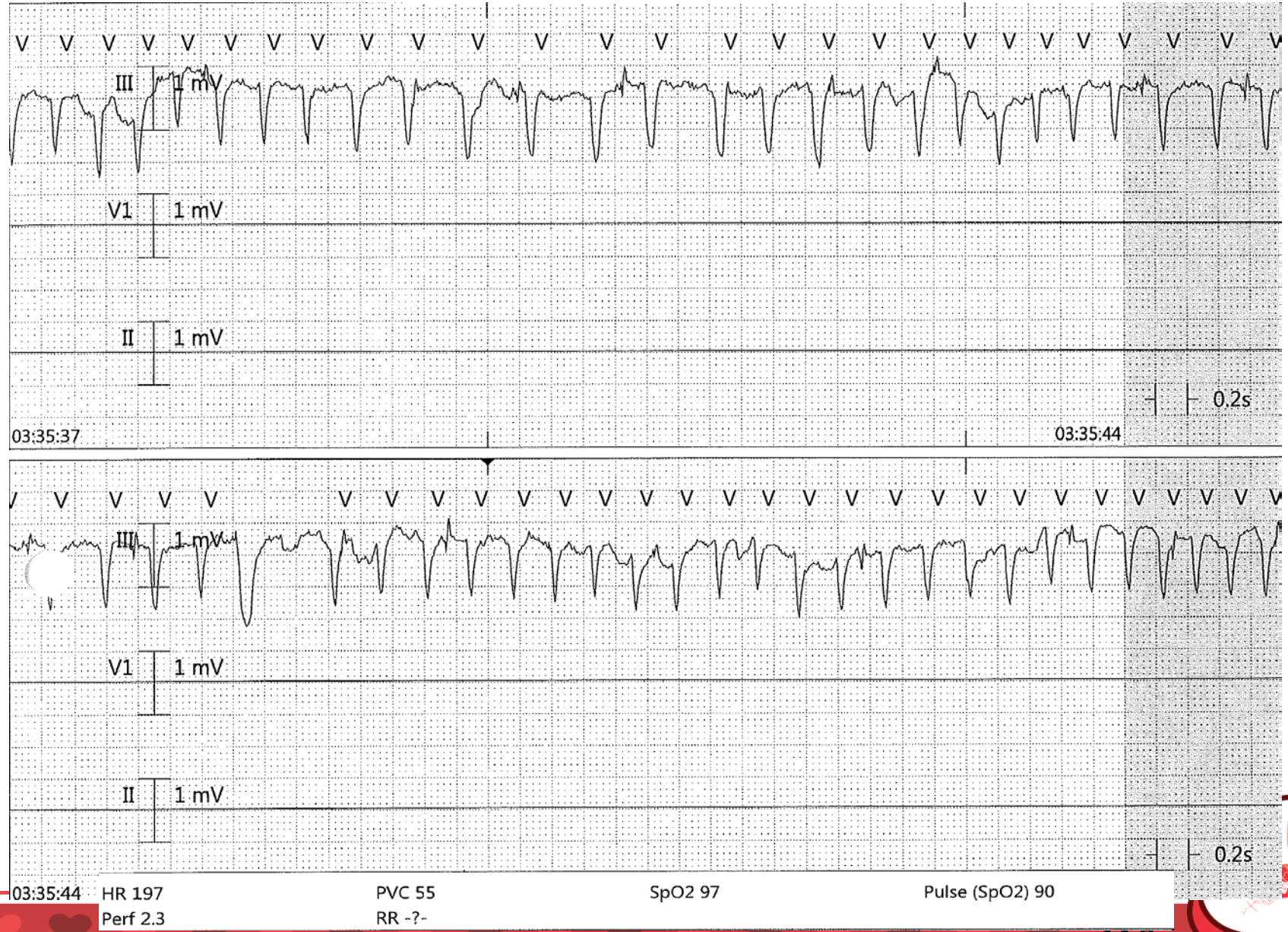
- Common ECG Missteps
  - Old infarct
  - Heart blocks
  - Wide complex tachycardia
  - ST elevation on ECG

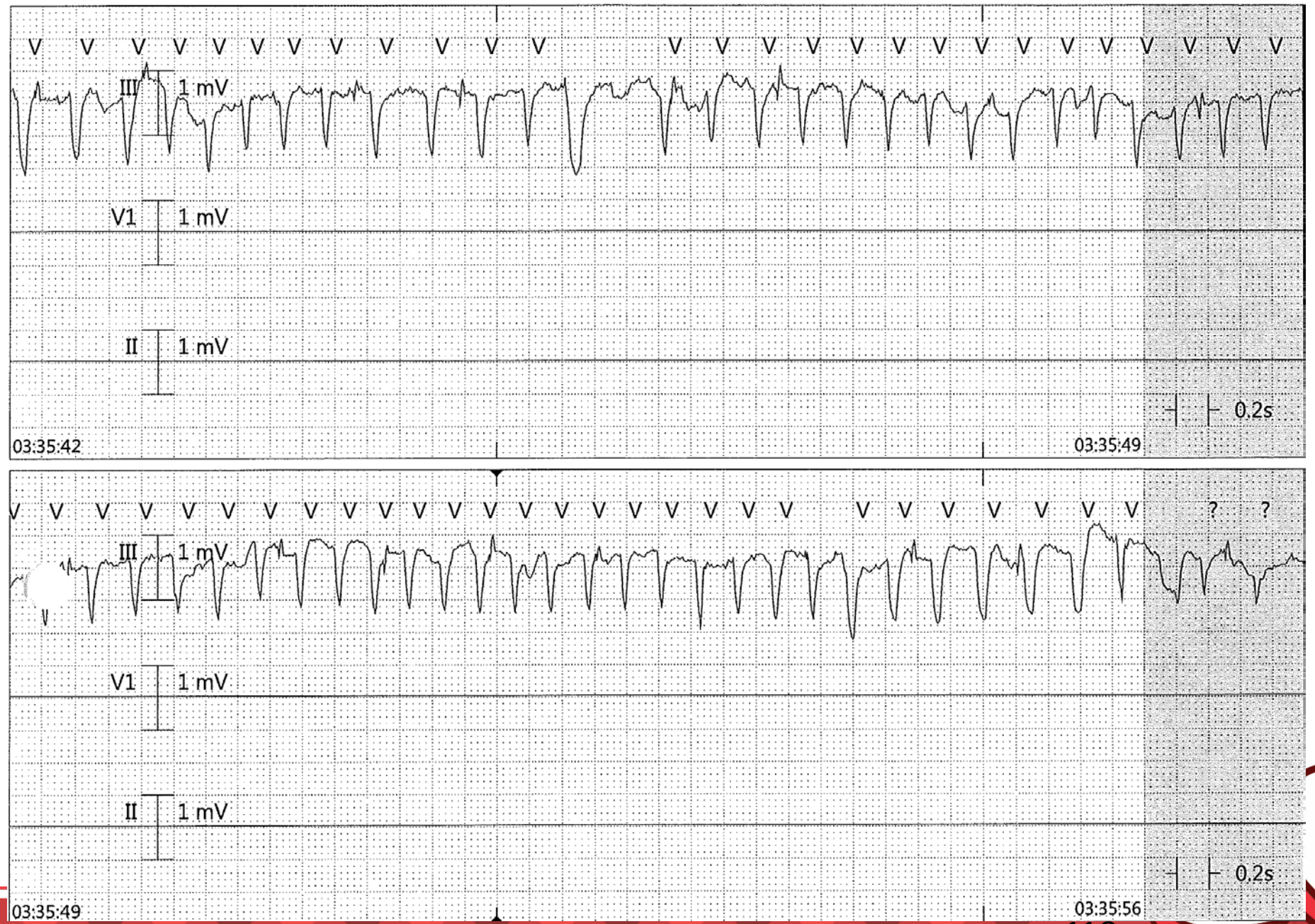
- Common Telemetry Missteps
  - Artifact
  - Inaccurate HR

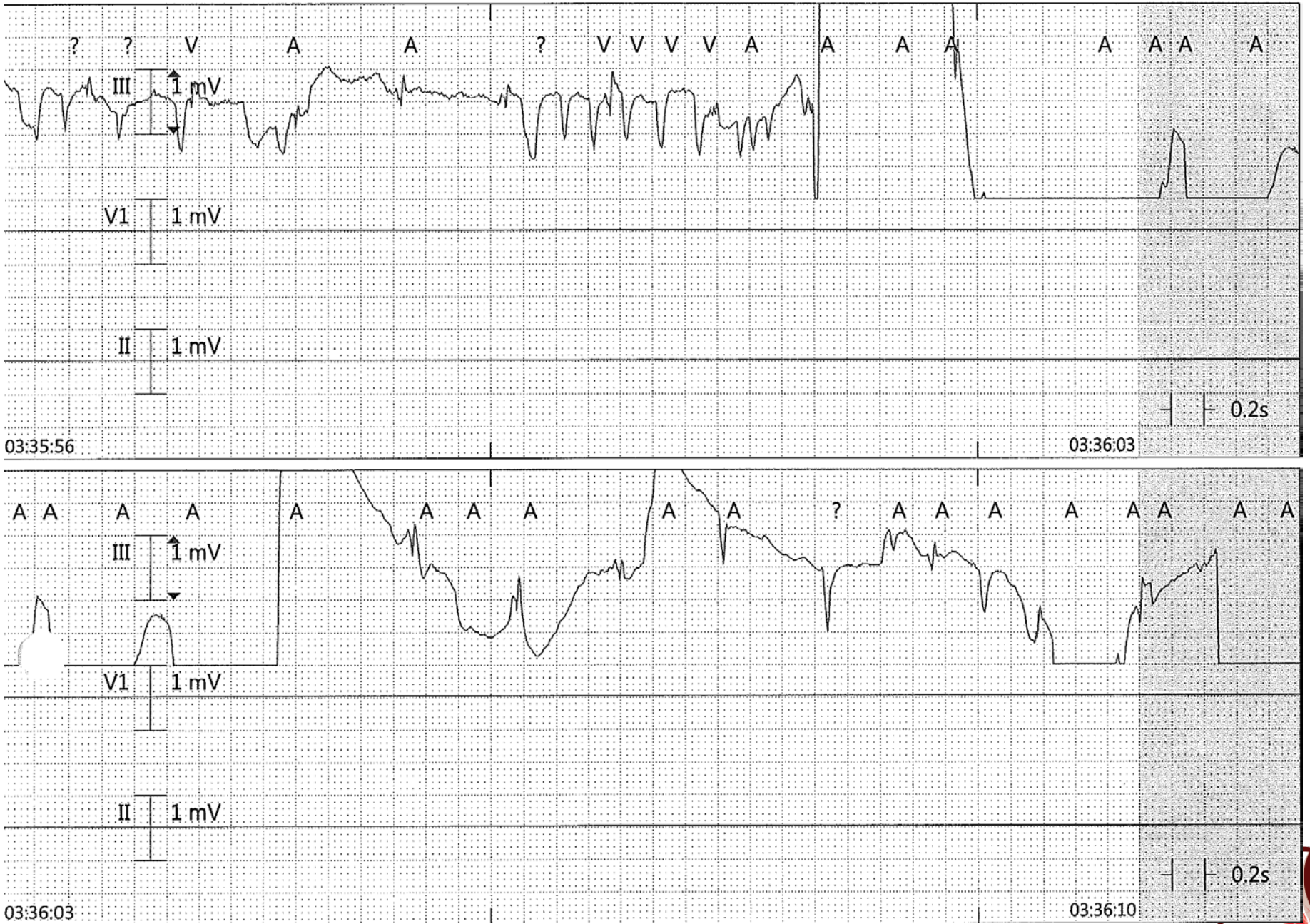
New consult for “ Atrial Fibrillation”



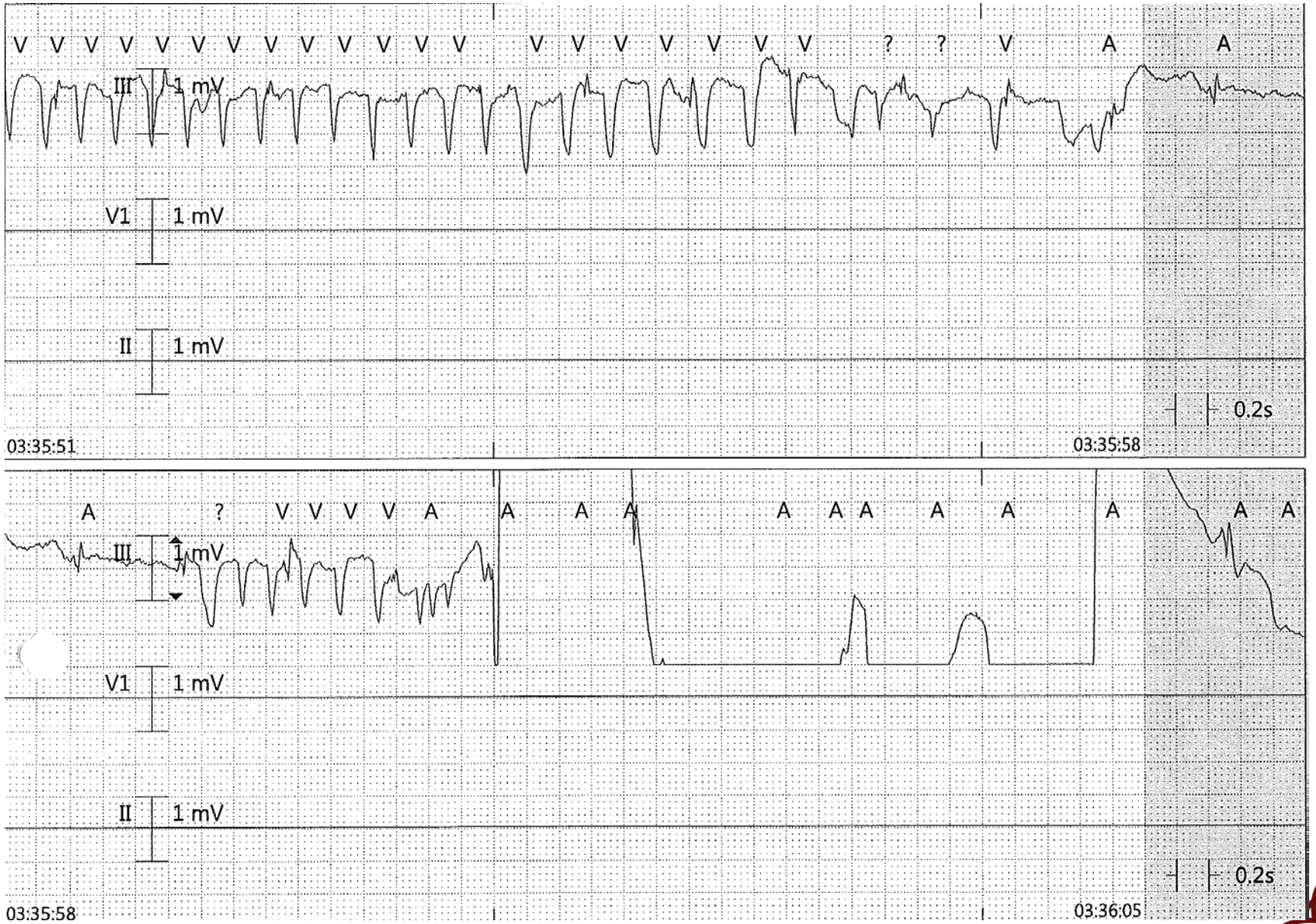
What is the Rhythm?

1. Atrial fibrillation with RVR
2. Atrial Flutter with RVR
3. Polymorphic VT
4. None of the above


HR 181
PVC 67
SpO2 96
Pulse (SpO2) 91
Perf 2.3
RR -?-
III 1 mV
V1 1 mV
II 1 mV
0.2s
03:35:42
03:35:49
III 1 mV
V1 1 mV
II 1 mV
0.2s
03:35:49
03:35:56



LOVERS AT HEART

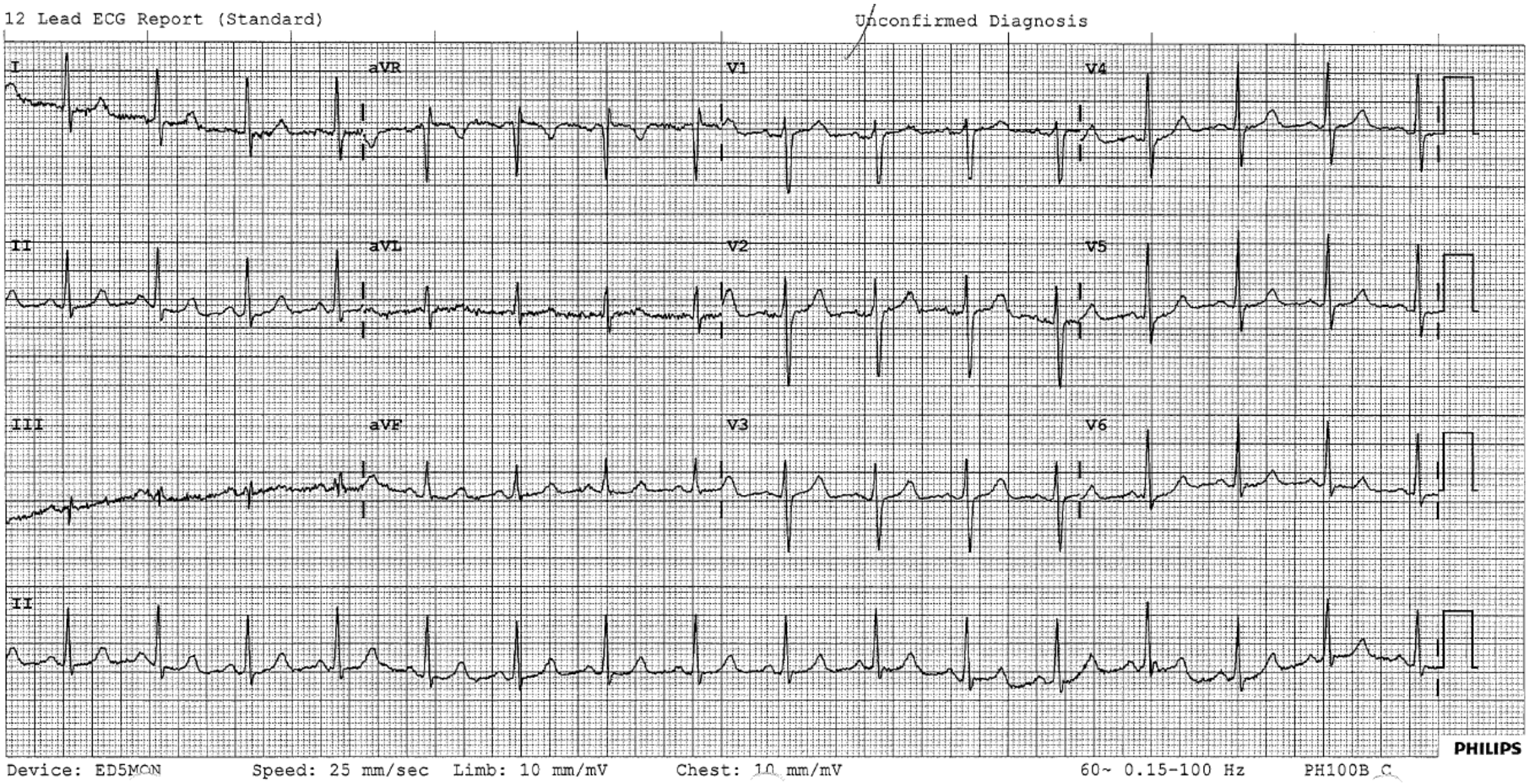


Baseline wander/artifact

Non physiologic RR intervals

Concordance in other ECG leads

What was the patient doing at this time ?

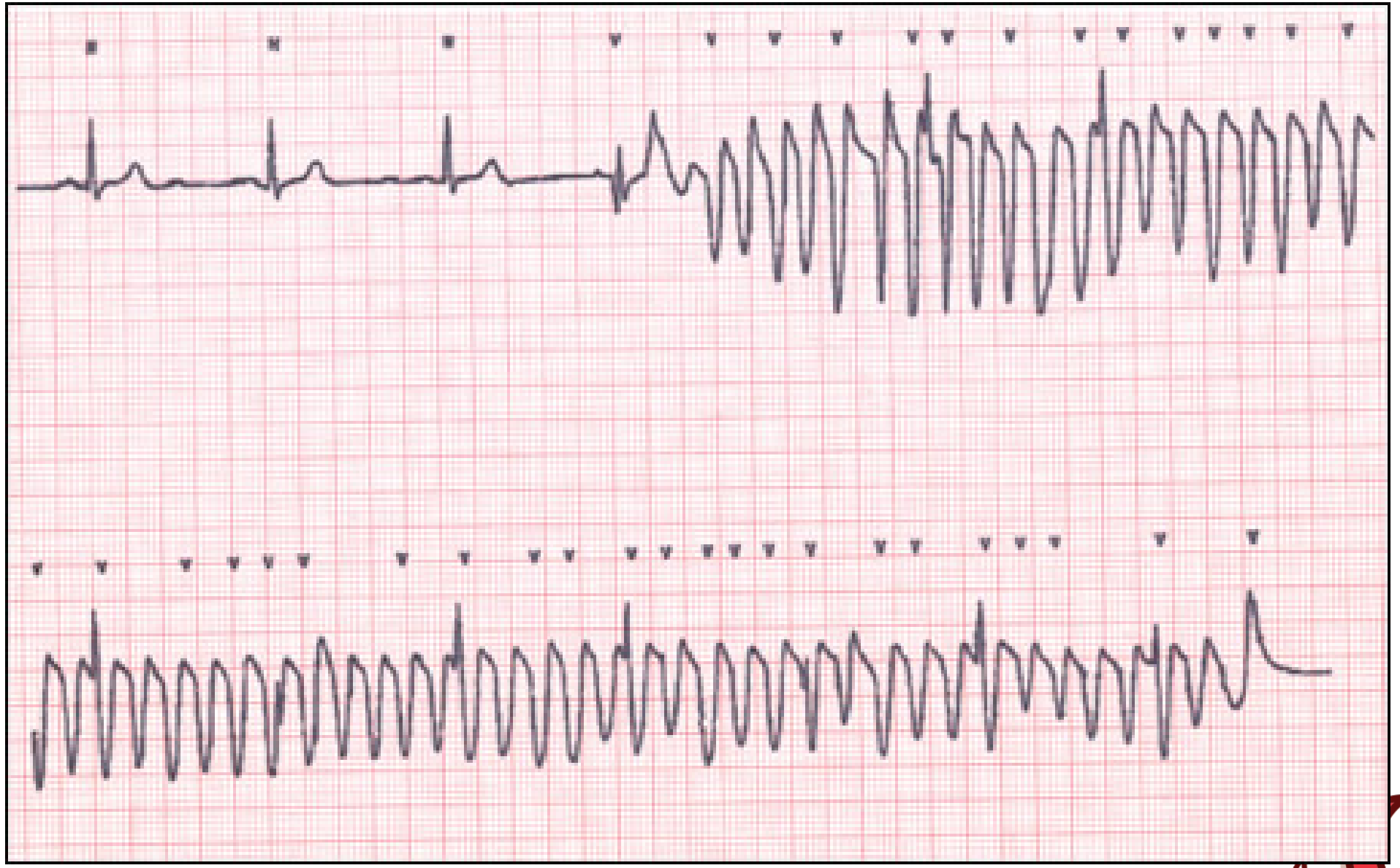

12 Lead ECG Report (Standard)
Unconfirmed Diagnosis
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
PHILIPS
Device: ED5MON
Speed: 25 mm/sec
Limb: 10 mm/mV
Chest: 10 mm/mV
60~ 0.15-100 Hz
PH100B C

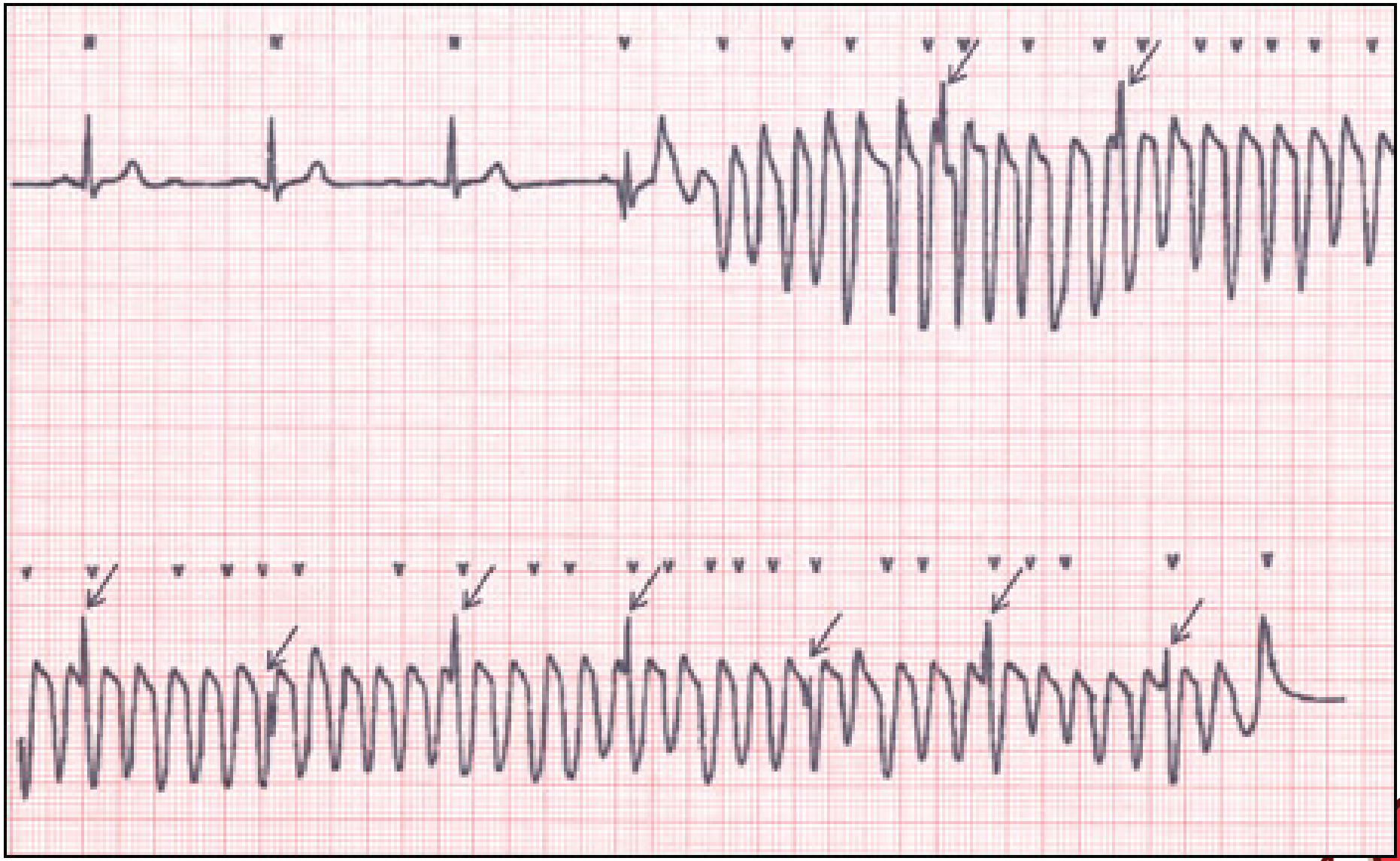
Wat je niet kent, herken je niet” .

- “What you do not know, you do not recognize.”

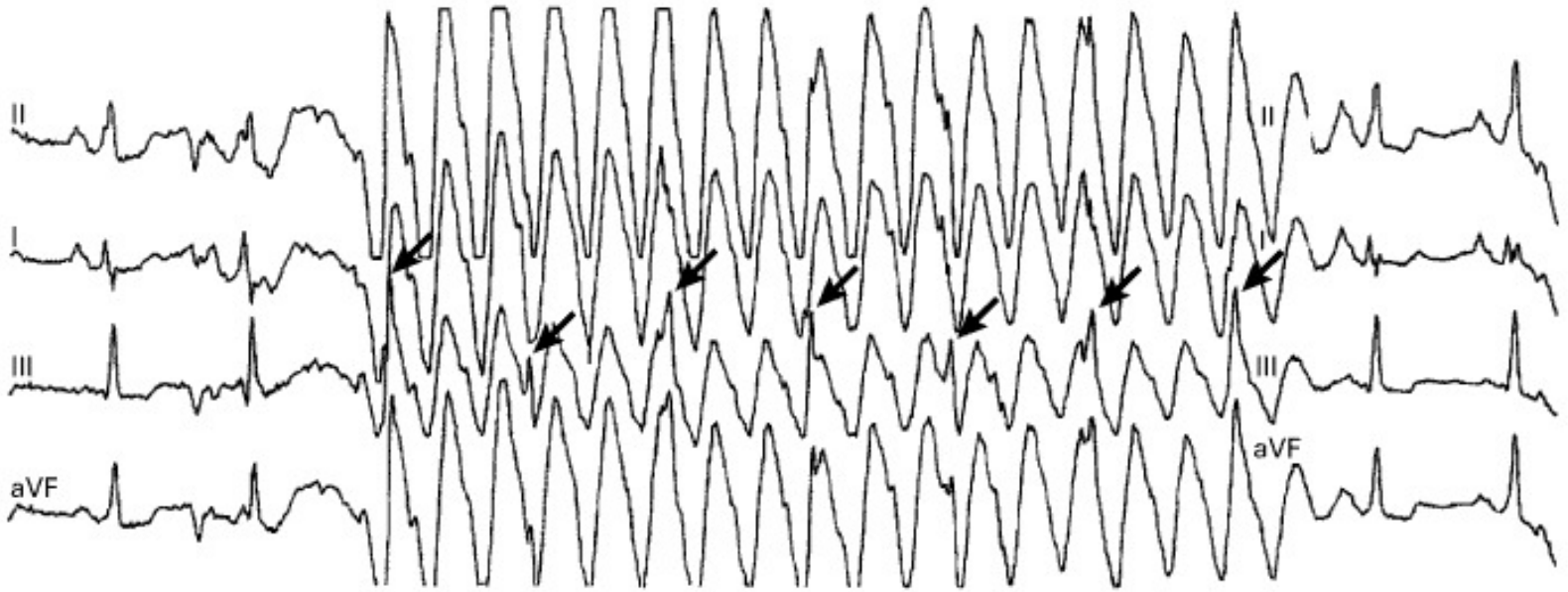
Reminder to students of electrocardiography, inscribed in the lecture hall of Professor Hein J.J. Wellens, MD.

Muscle tremor artifact





Rhythm Strip of Electrocardiographic Artifact That Mimicked Monomorphic Ventricular Tachycardia and Led to the Patient's Being Treated with Lidocaine.



Electrocardiographic artifact mimicking ventricular tachycardia.

QRS complexes are hidden by pseudo-QRS complexes in most of the leads except in in lead II (asterisks).

Rhythm Strip of Electrocardiographic Artifact That Mimicked Polymorphic Ventricular Tachycardia and Led to the Patient's Being Treated with Lidocaine.

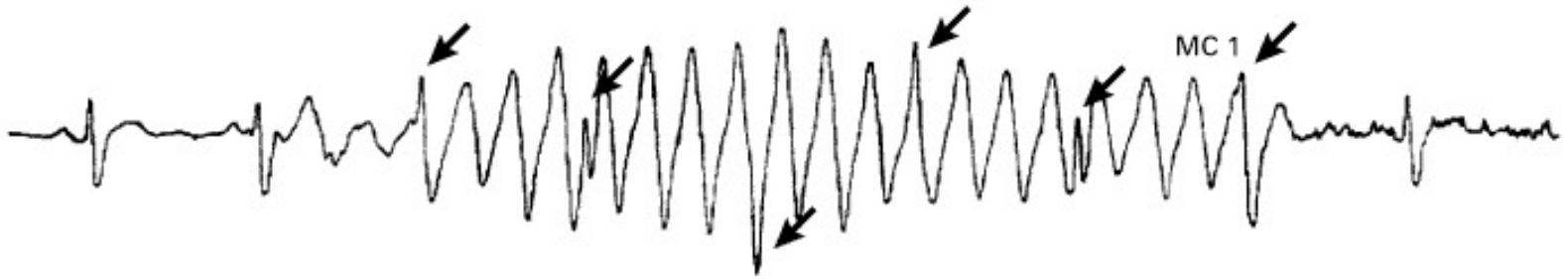


TABLE 1. CHARACTERISTICS OF THE PATIENTS, FEATURES OF THE ELECTROCARDIOGRAPHIC ARTIFACT, AND CONSEQUENCES TO THE PATIENT OF THE MISDIAGNOSIS OF ARTIFACT AS VENTRICULAR TACHYCARDIA.*

PATIENT NO.	CHARACTERISTICS OF THE PATIENT					FEATURES OF THE ARTIFACT							CONSEQUENCES
	AGE (YR)/ SEX	PROBLEM AT ADMISSION	HEART DISEASE	LVEF (%)	LOCATION	MONOMORPHIC OR POLYMORPHIC	ASSOCIATED SYMPTOMS	NO. OF BEATS	RATE (bpm)	ONSET RECORDED	TERMINATION RECORDED	RECURRENT	
1	74/F	Syncope	None	60	Ward	Polymorphic	None	11	200	Yes	Yes	No	Lidocaine, implantation of permanent pacemaker
2	54/M	Syncope	CAD	25	Ward	Monomorphic	None	18	180	Yes	Yes	Yes	Lidocaine
3	41/F	Presyncope	None	60	Ward	Polymorphic	None	24	280	Yes	Yes	No	Placement of ICD
4	40/M	Palpitations	None	60	Ward	Monomorphic	None	24	220	Yes	Yes	Yes	Lidocaine, admission to ICU, referral for electrophysiologic test
5	38/F	Chest pain	None	—	Ward	Polymorphic	Arm paresthesias	31	220	No	Yes	Yes	Sublingual nitroglycerin, referral for electrophysiologic test
6	53/M	Cardiac arrest	DCM	20	Ward	Monomorphic	None	13	250	Yes	Yes	No	Blood transfusion
7	59/F	Post-CABG	CAD	25	Ward	Polymorphic	None	19	280	Yes	Yes	No	Lidocaine
8	71/F	Chest pain	None	60	Emergency department	Polymorphic	Chest pain	26	220	Yes	Yes	Yes	Precordial thump, lidocaine, transfer for electrophysiologic test
9	65/M	Respiratory arrest, COPD	None	60	Emergency department	Polymorphic	Unresponsive	33	250	No	No	No	Precordial thump, lidocaine, aspirin, intravenous nitroglycerin, cardiac catheterization, referral for ICD
10	54/F	Visual changes, confusion	CAD	55	Emergency department	Monomorphic	None	15	190	Yes	Yes	Yes	Lidocaine, cardiac catheterization, transfer for electrophysiologic test
11	84/M	Abnormal Holter-monitor recording	CAD	—	Outpatient Holter-monitor recording	Monomorphic	None	26	240	No	Yes	No	Admission to hospital from home, referral for electrophysiologic test
12	50/M	Not applicable	None	60	Outpatient treadmill test	Polymorphic	None	18	180	Yes	Yes	Yes	Cardiac catheterization

*LVEF denotes left ventricular ejection fraction, bpm beats per minute, CAD coronary artery disease, ICD implantable cardioverter–defibrillator, ICU intensive care unit, DCM dilated cardiomyopathy, CABG coronary-artery bypass grafting, and COPD chronic obstructive pulmonary disease.

CLINICAL STUDIES

Physician Interpretation of Electrocardiographic Artifact That Mimics Ventricular Tachycardia

Bradley P. Knight, MD, Frank Pelosi, MD, Gregory F. Michaud, MD, S. Adam Strickberger, MD, Fred Morady, MD

Figure 1. Two-lead surface electrogram included in the physician questionnaire that depicts electrocardiographic artifact simulating monomorphic ventricular tachycardia. Four QRS complexes (**arrows**) and corresponding T waves (**arrowheads**) were visible within the artifact at intervals that equal the cycle length of the sinus rhythm preceding the artifact. The arrows and arrowheads were not included in the questionnaire.

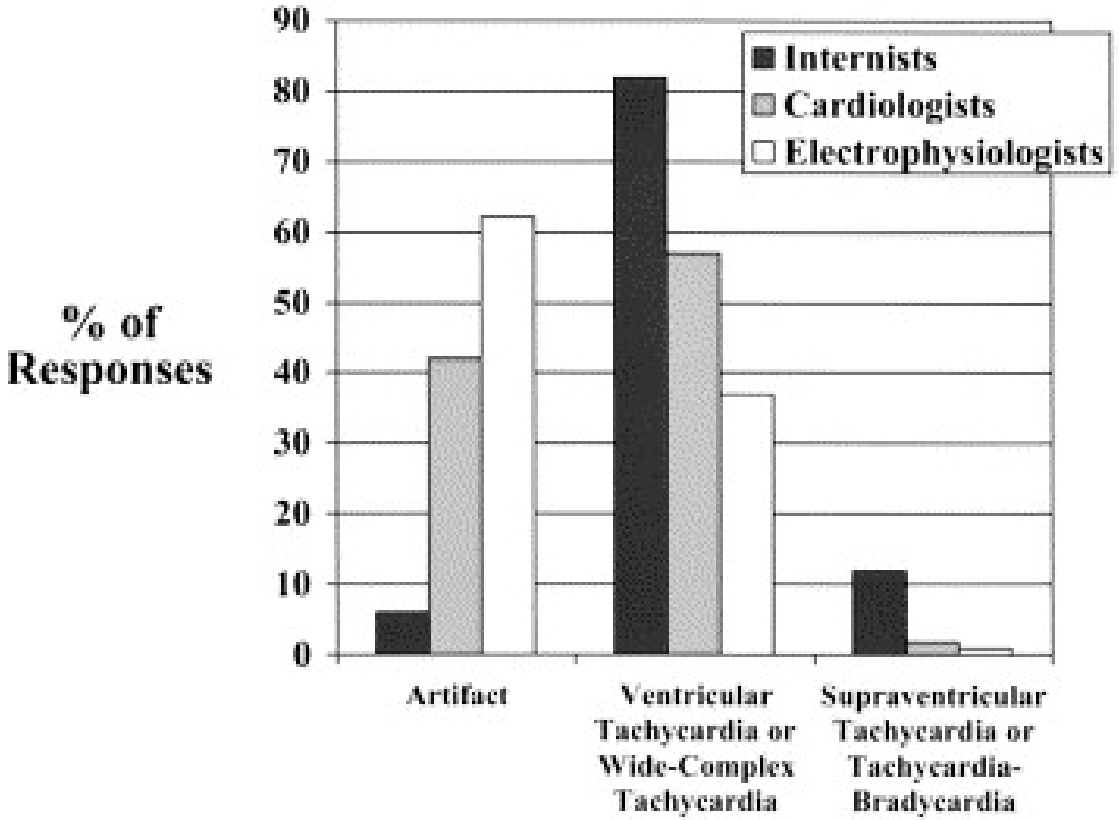
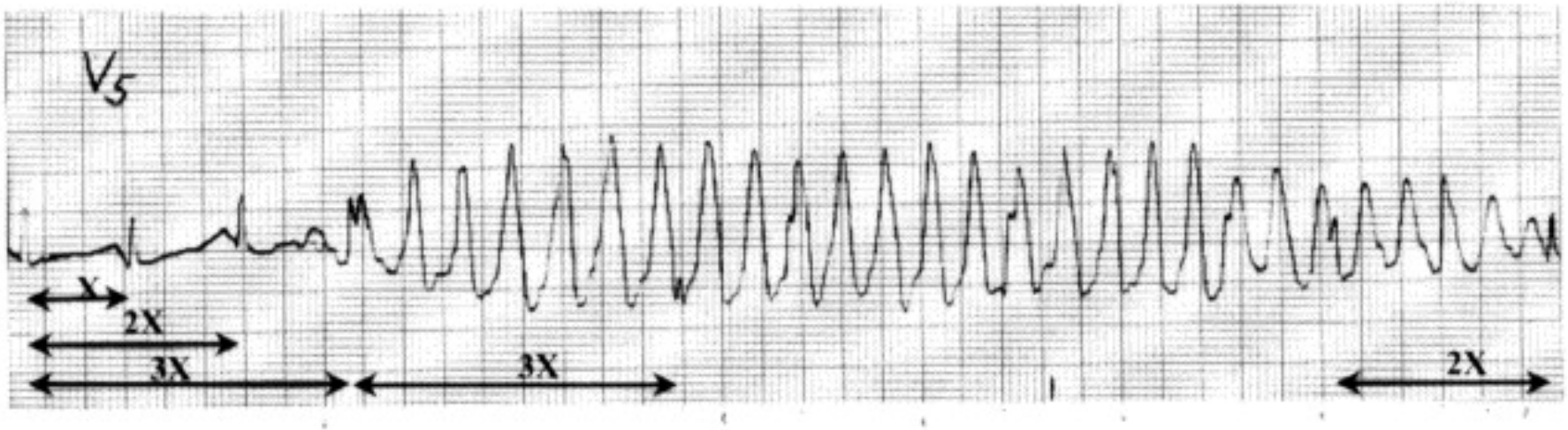
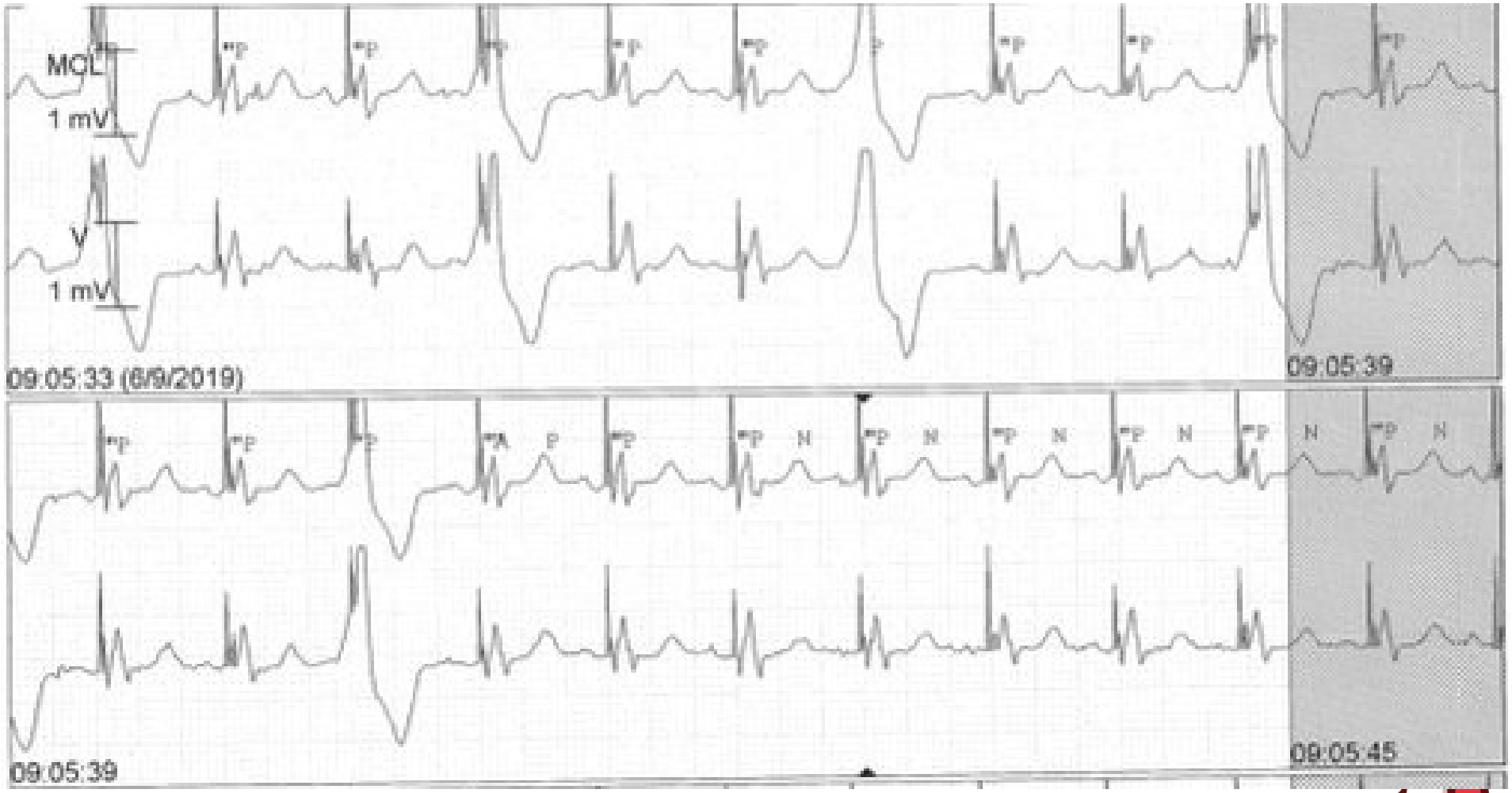


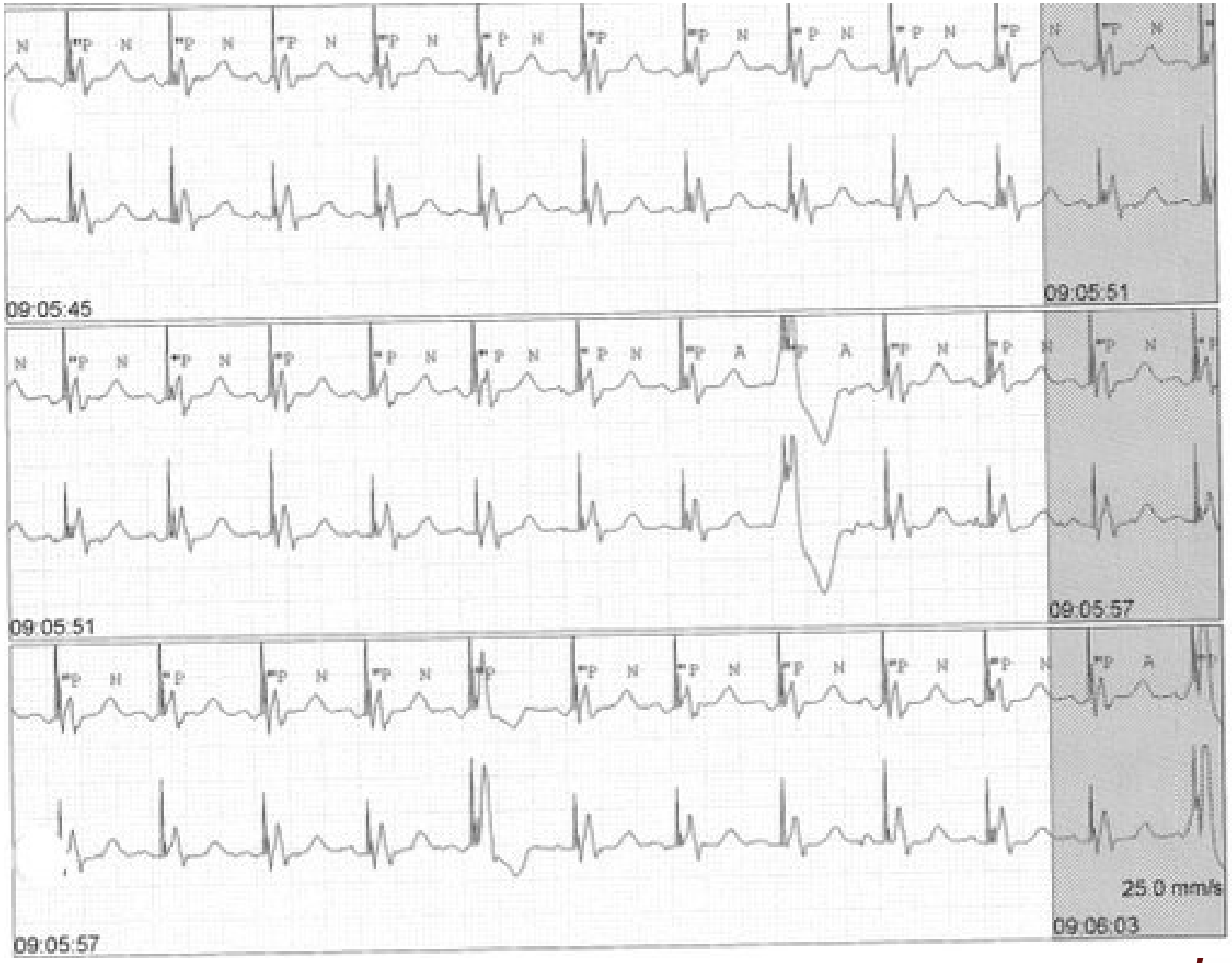
Figure 2. Diagnoses made by 55 internists, 221 cardiologists, and 490 electrophysiologists to a questionnaire that depicted an electrocardiogram of artifact.

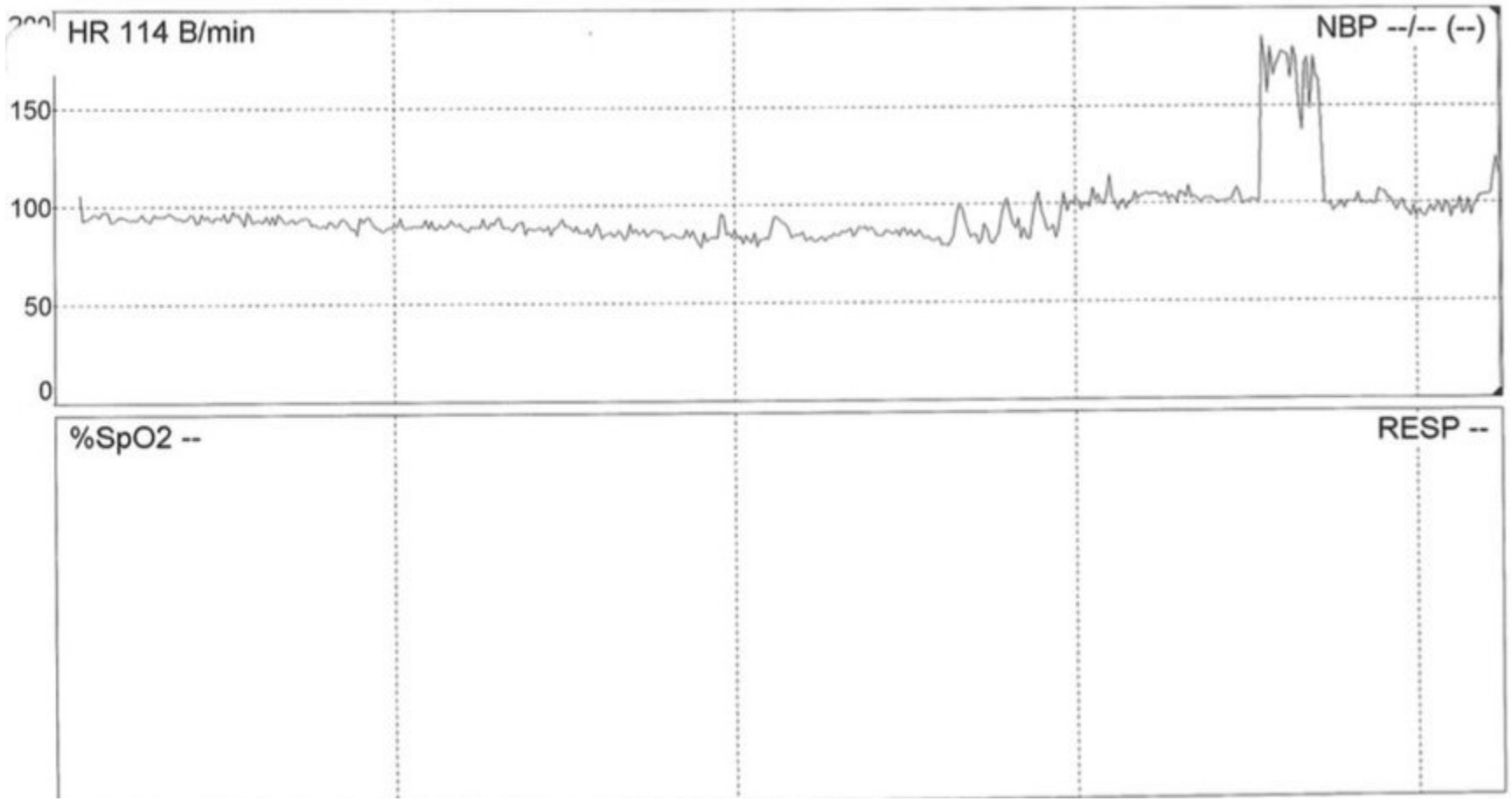


An example of electrocardiographic artifact that is difficult to differentiate from ventricular tachycardia. QRS complexes cannot be identified at every expected interval within the artifact. However, discrete components of the QRS complexes are visible at intervals that correspond to multiples of the baseline rhythm RR interval. X denotes the baseline RR interval.

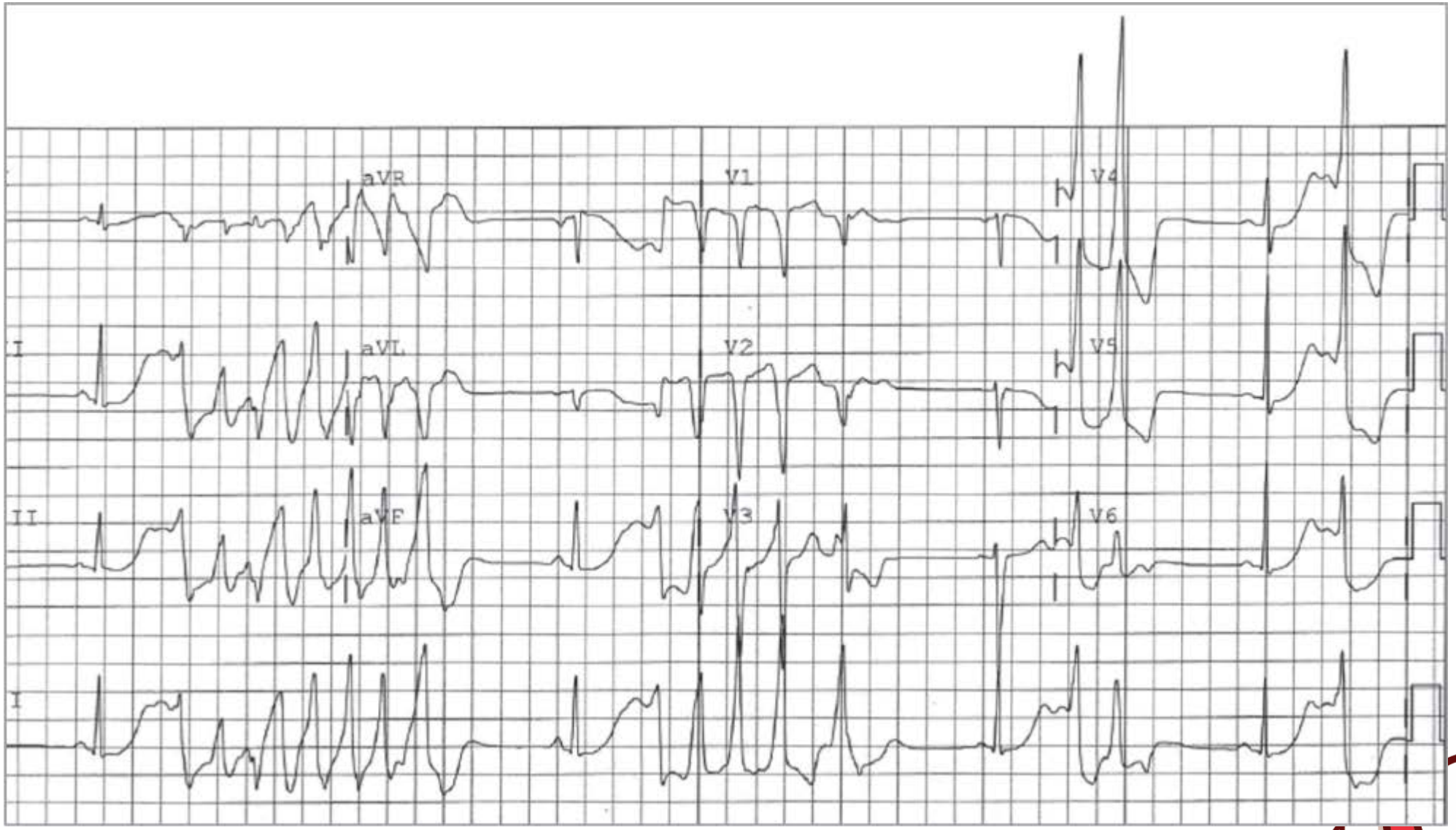
Called for abrupt onset of “ Rapid Tachycardia”



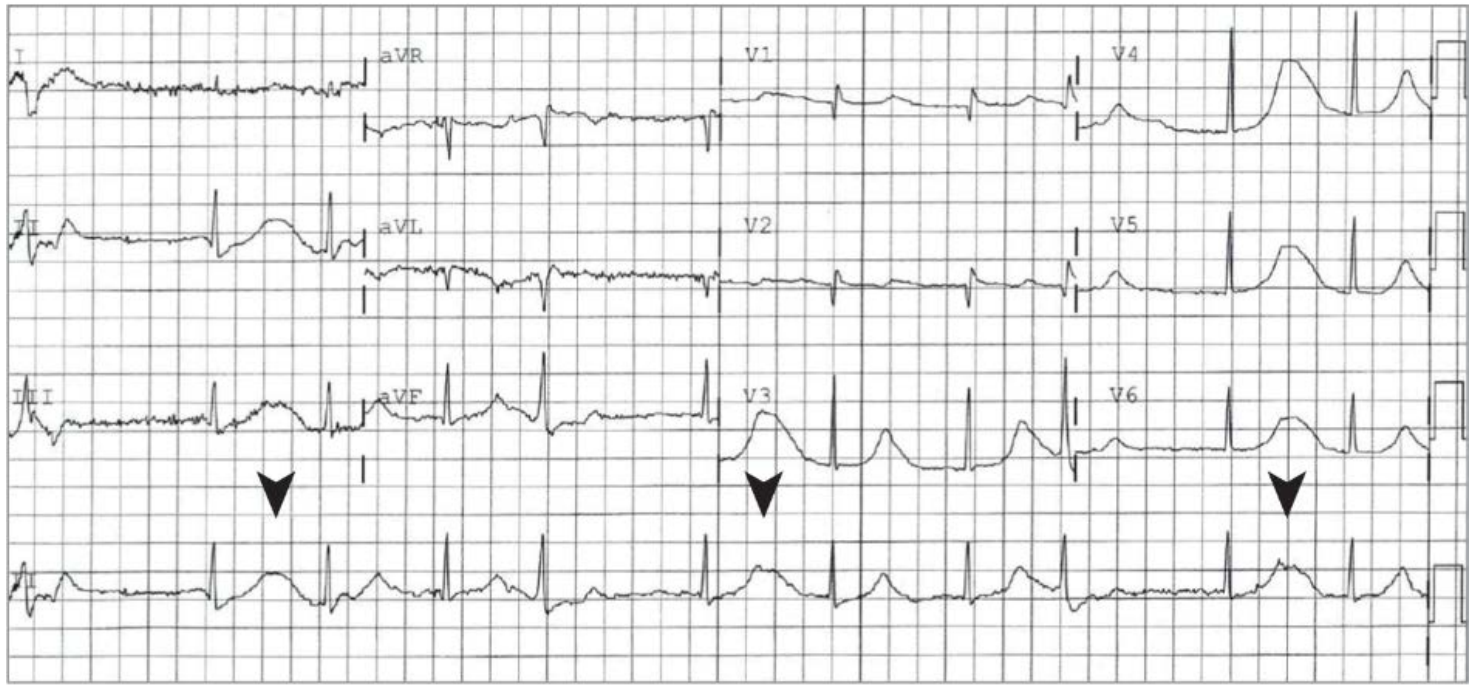

09:05:45
09:05:51
09:05:51
09:05:57
09:05:57
25.0 mm/s
09:06:03


HR 114 B/min
NBP --/-- (--)
150
100
50
0
%SpO2 --
RESP --

True VT- Not artifact

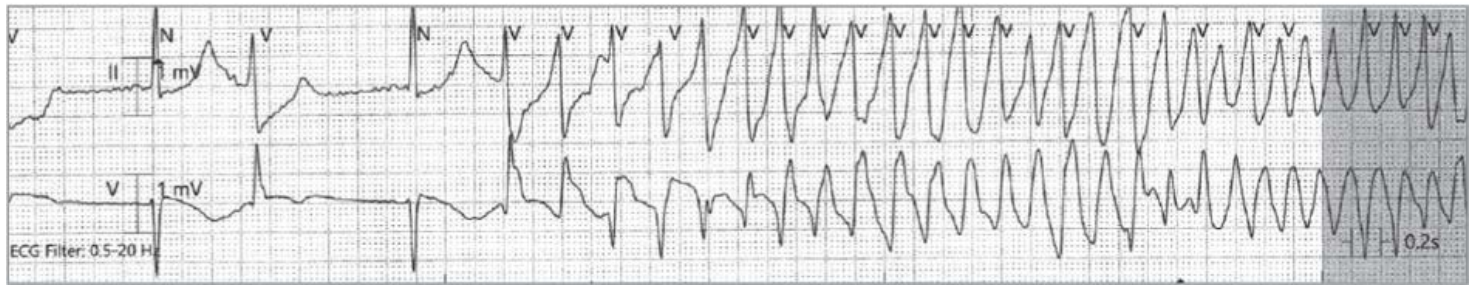


A Electrocardiogram



Subsequent Electrocardiogram (ECG) and Telemetry StripA, The ECG was recorded 4 hours after patient presentation; the arrowheads represent giant TU waves,

B Telemetry strip

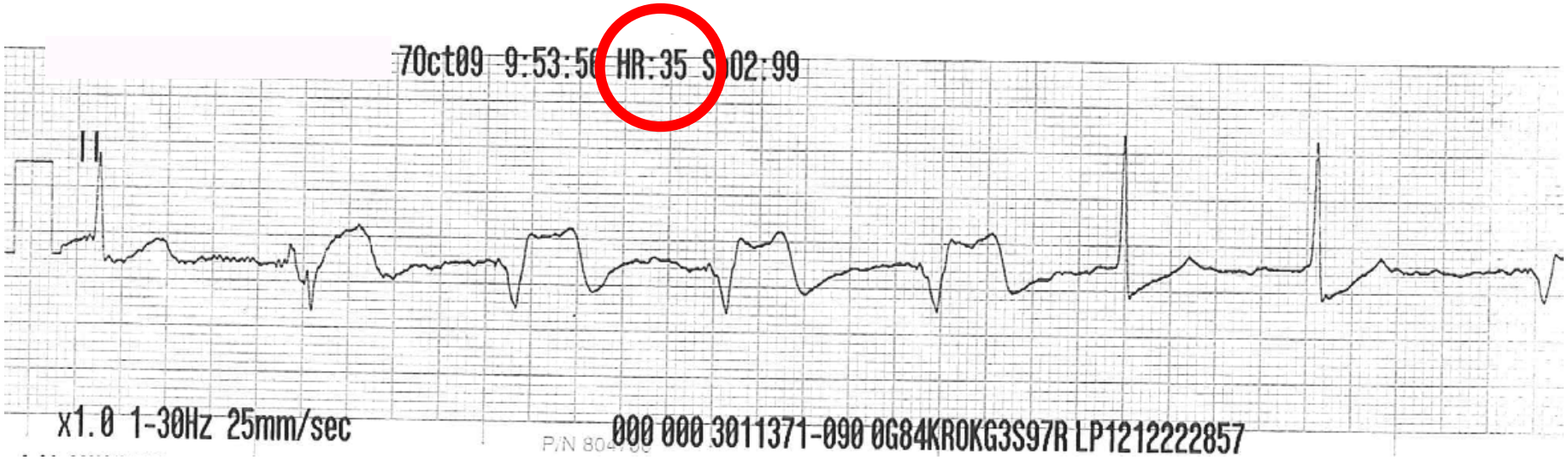


B, Telemetry strip documenting initiation of torsades de pointes.

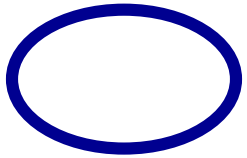
From: **Electrocardiographic Harbingers of Ventricular Tachycardia Arrest—A Moment of Pause**

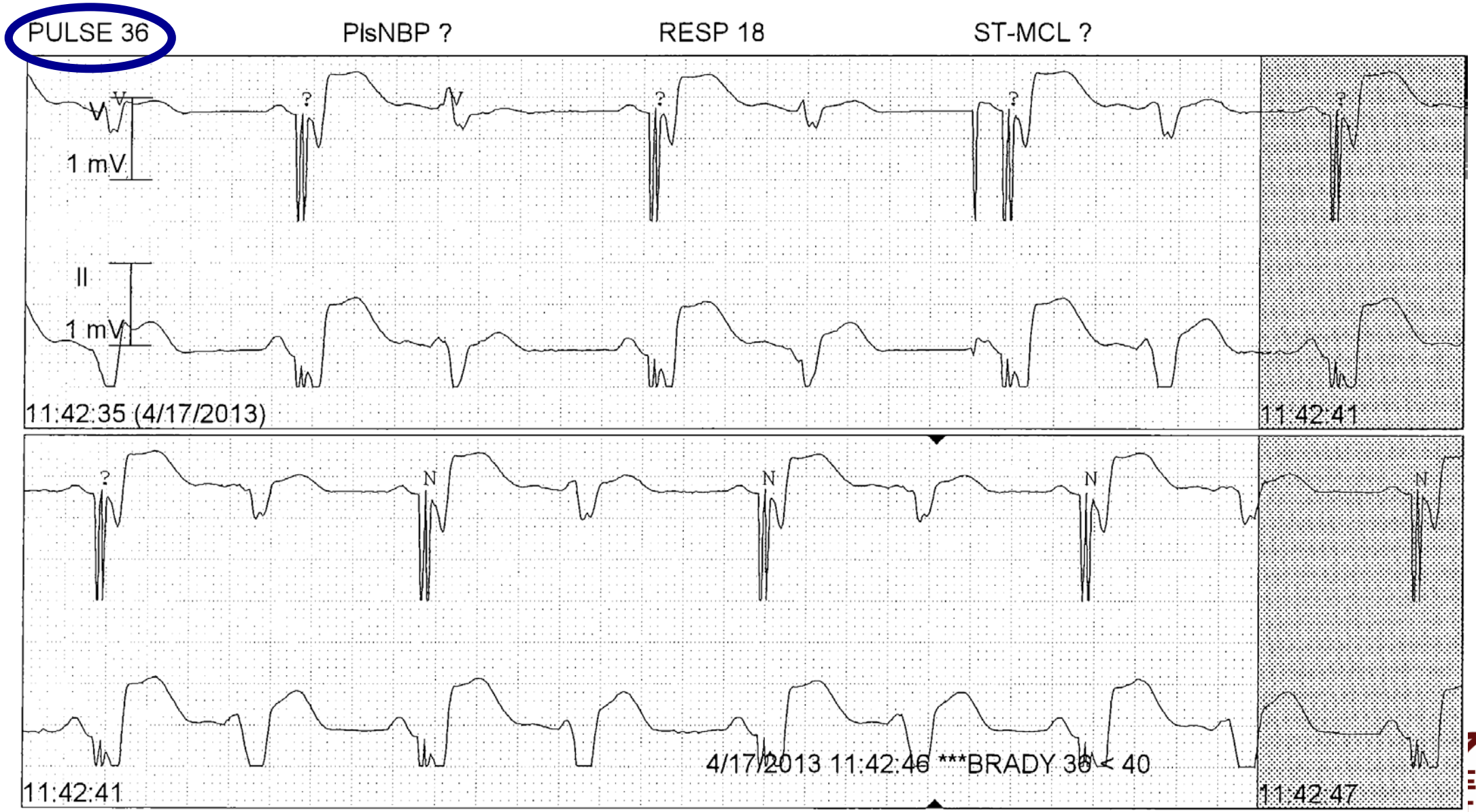
JAMA Intern Med. 2019;179(2):249-251. doi:10.1001/jamainternmed.2018.6220

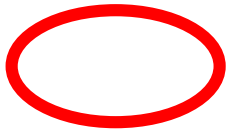
She doesn't have a pacemaker!



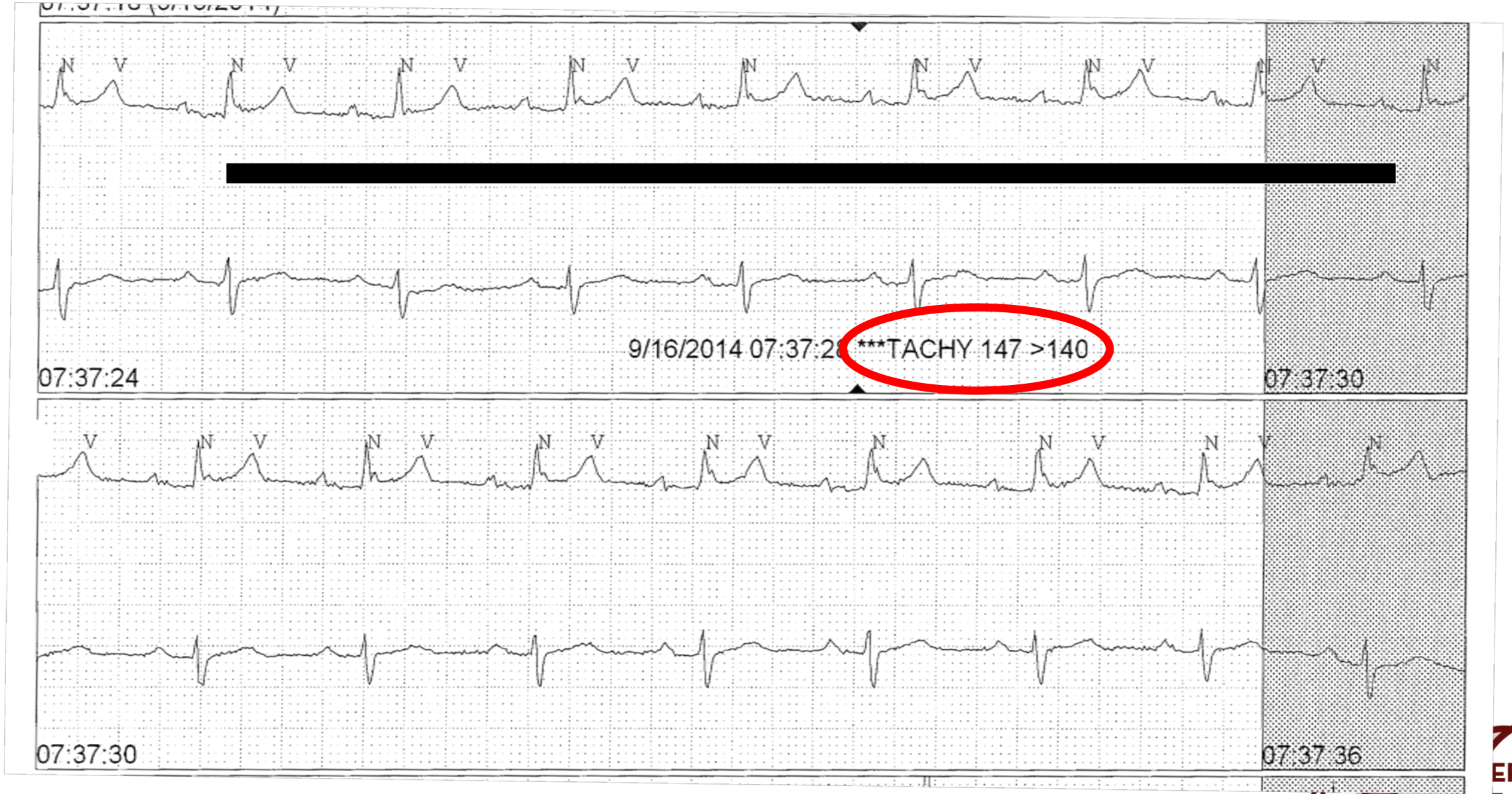
Telemetry under sensing



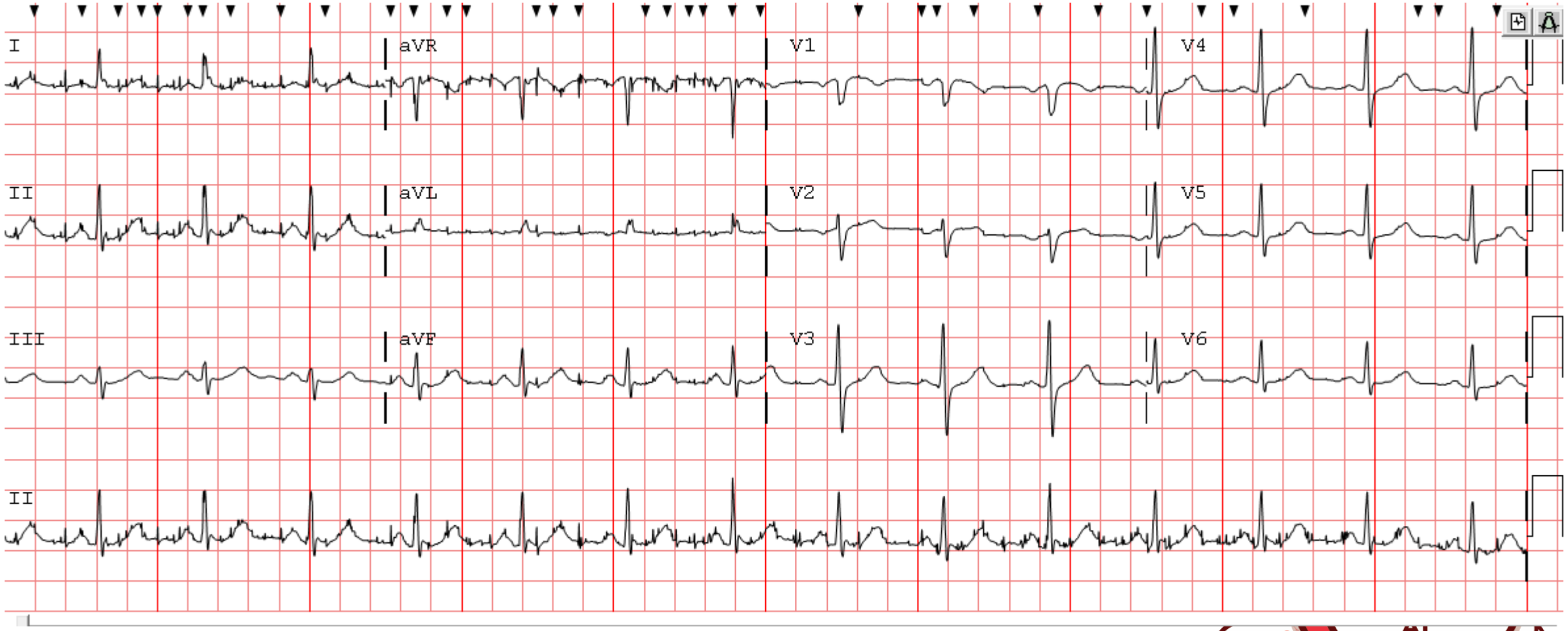

PULSE 36
PlsNBP ?
RESP 18
ST-MCL ?
1 mV
II
1 mV
11:42:35 (4/17/2013)
11:42:41
11:42:41
4/17/2013 11:42:46 ***BRADY 38 < 40
11:42:47




LOVERS
AT
HEART


N V N V N V N V N N V N V N V
9/16/2014 07:37:28 ***TACHY 147 >140
07:37:24
07:37:30
V N V N V N V N V N N V N V N
07:37:30
07:37:36

If ECG or telemetry says pacemaker malfunction : Check if they have a pacemaker first ☺



- Thank you