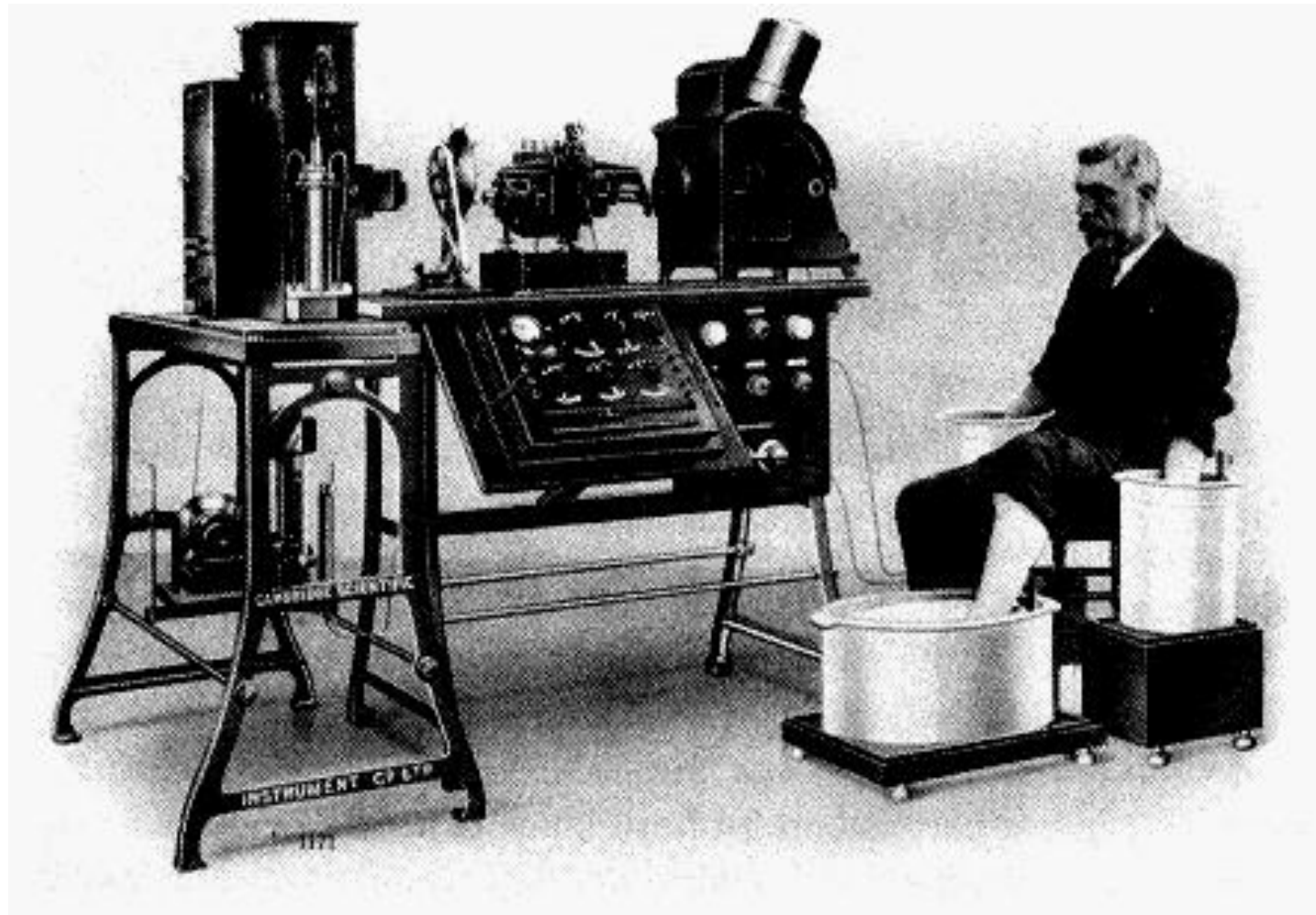
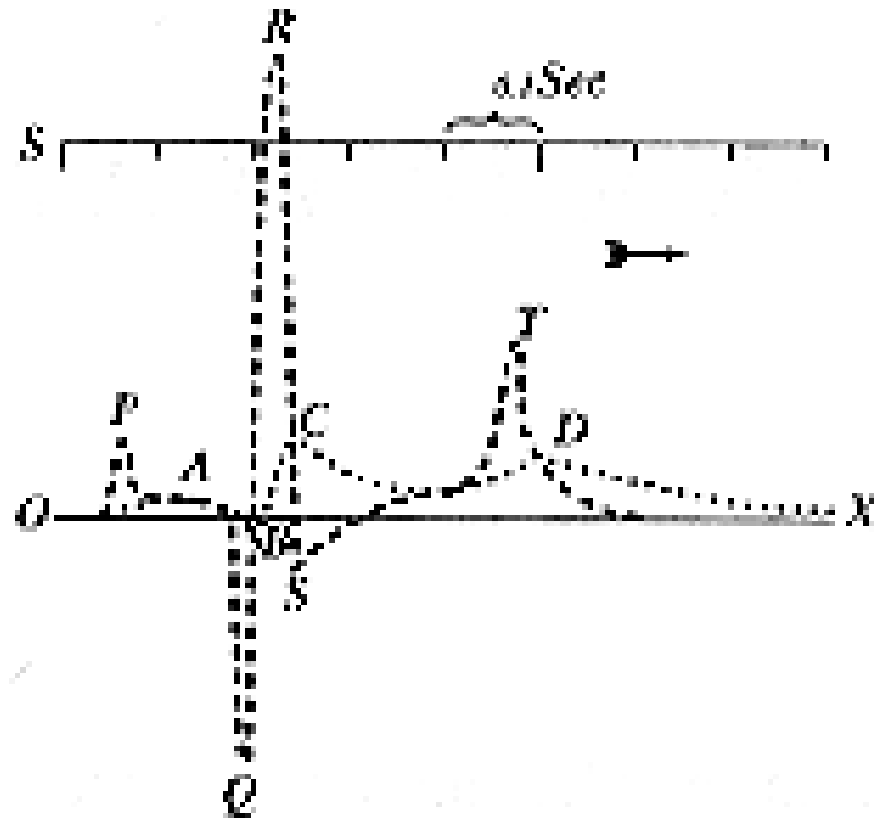


An early Electrocardiograph



Einthoven's first published EKG, 1902



“I do not however imagine that the string galvanometer...is likely to find any very extensive use in the hospital”

August D. Waller, 1909

The Electrocardiogram (ECG/EKG)

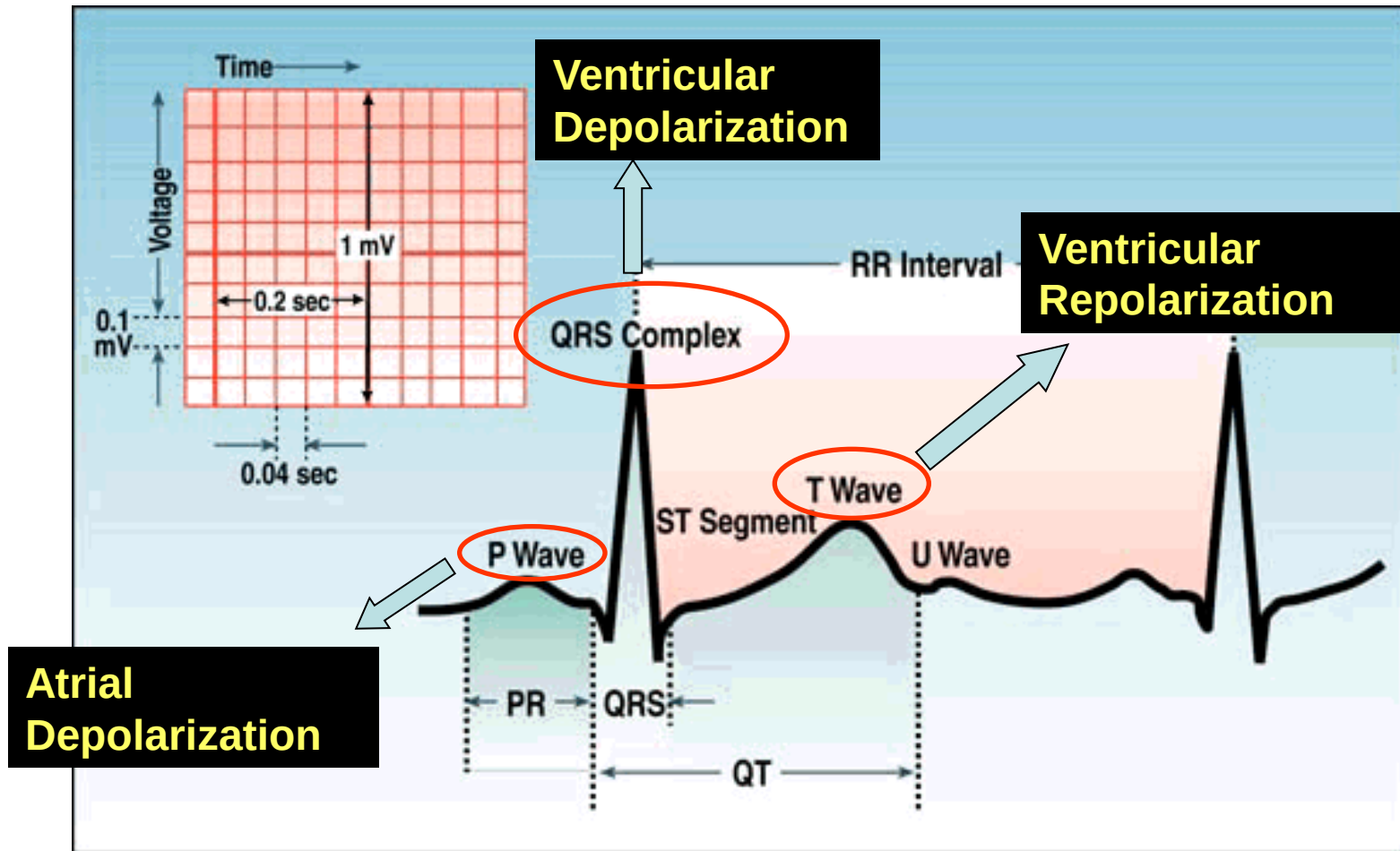
- Most Commonly Utilized Cardiovascular Lab Test
 - ♥ 100 Million Performed per Year
 - ♥ \$5 Billion Cost per Year
 - ♥ Reimbursements have dropped
 - ♥ Key to Therapy for ACS/MI
 - ♥ Diagnosis of Arrhythmias

Indications For An ECG

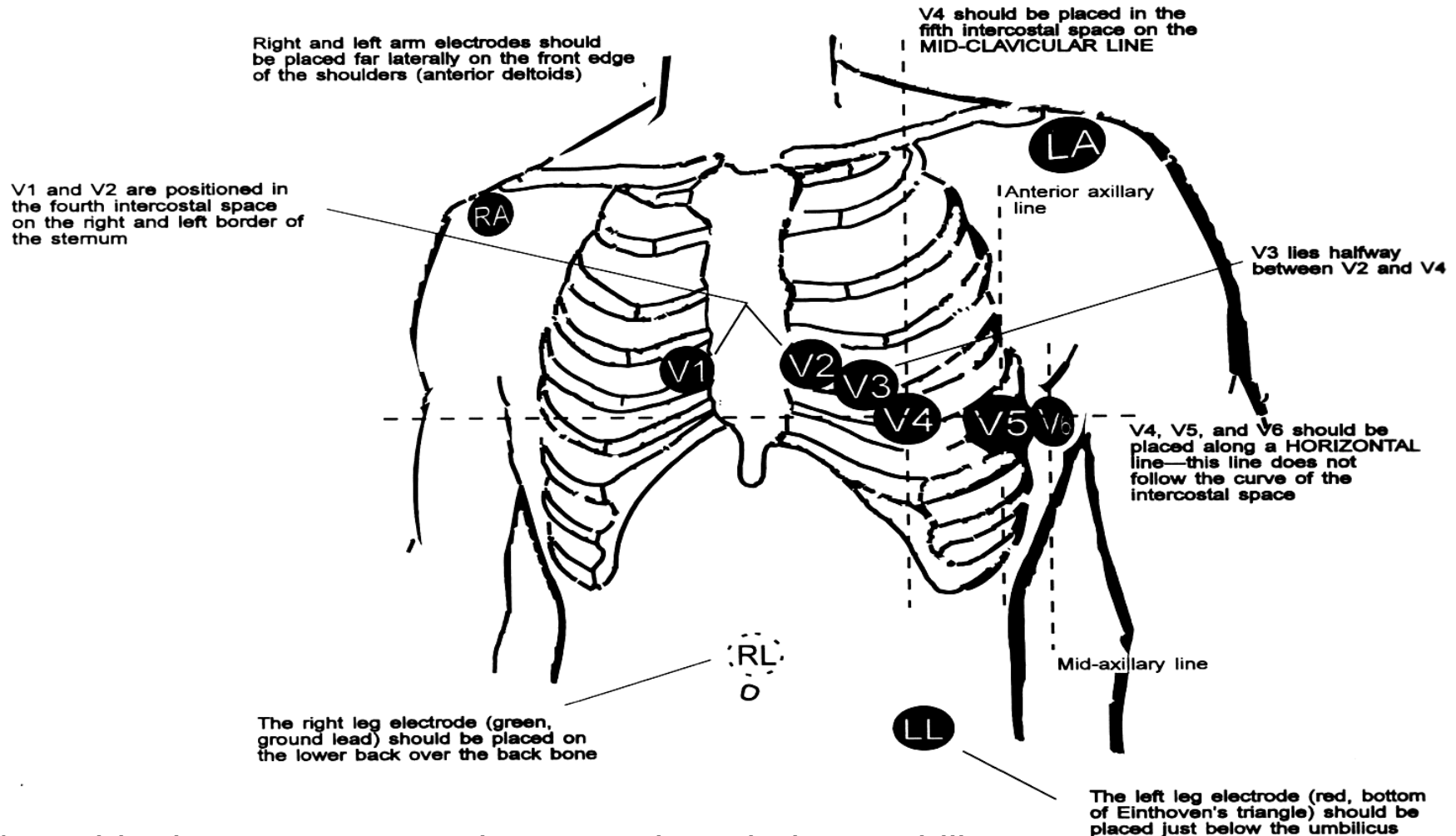
- ♥ Chest or Epigastric Pain or Sensation
- ♥ CHF Signs or Symptoms
- ♥ Abnormal Pulse
- ♥ Hypotension
- ♥ Unexplained Weakness
- ♥ Altered Mental State (Coma, CVA)
- ♥ Drug Overdose
- ♥ Chest Trauma
- ♥ Syncope or Near Syncope
- ♥ Systemic Illness
- ♥ Metabolic Disease

Screening??

P's and Q's of Electrocardiography



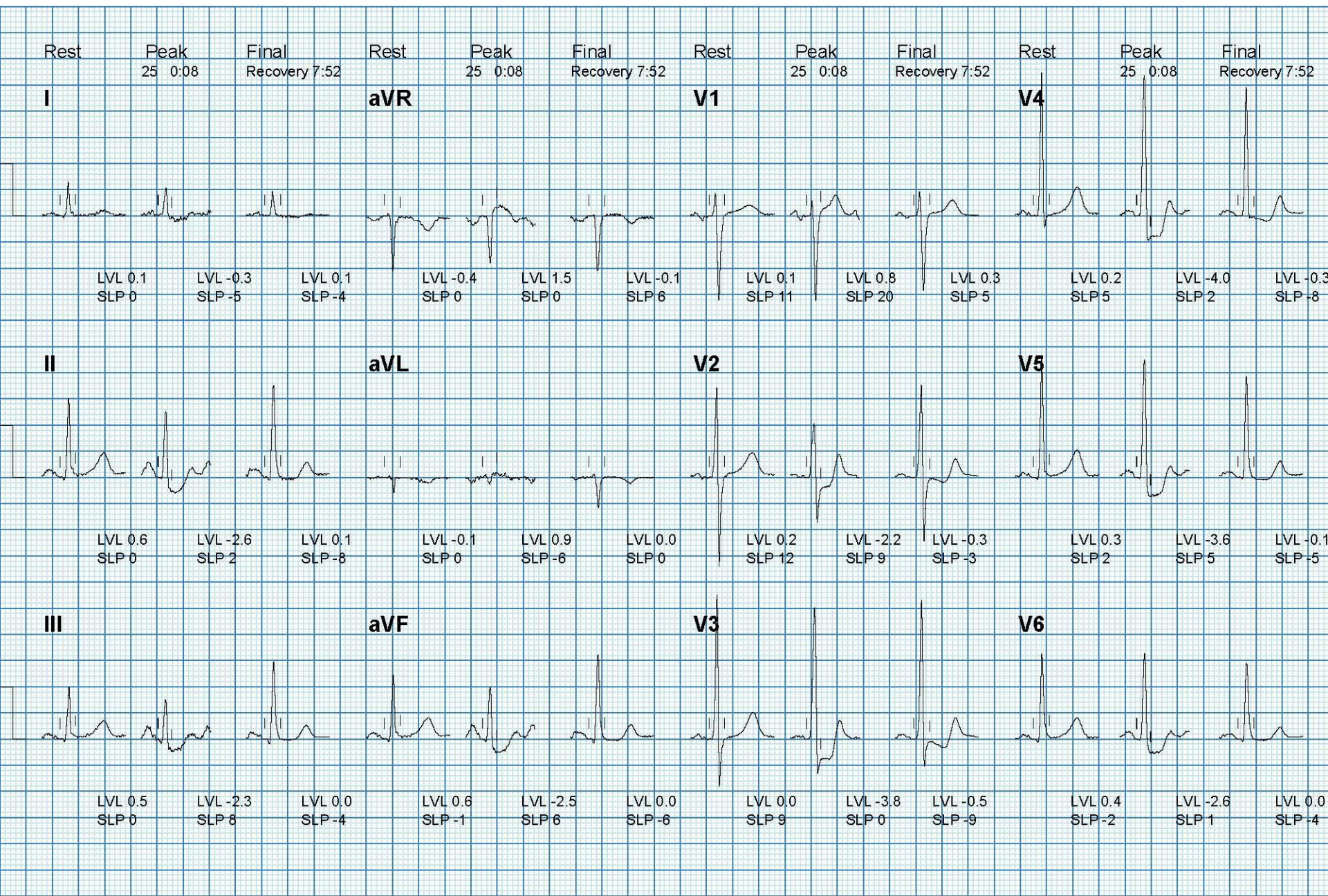
Lead Placement for the Standard 12-lead ECG



RL/LL- side does not matter, place anywhere below umbilicus

The Electrocardiogram (ECG/EKG)

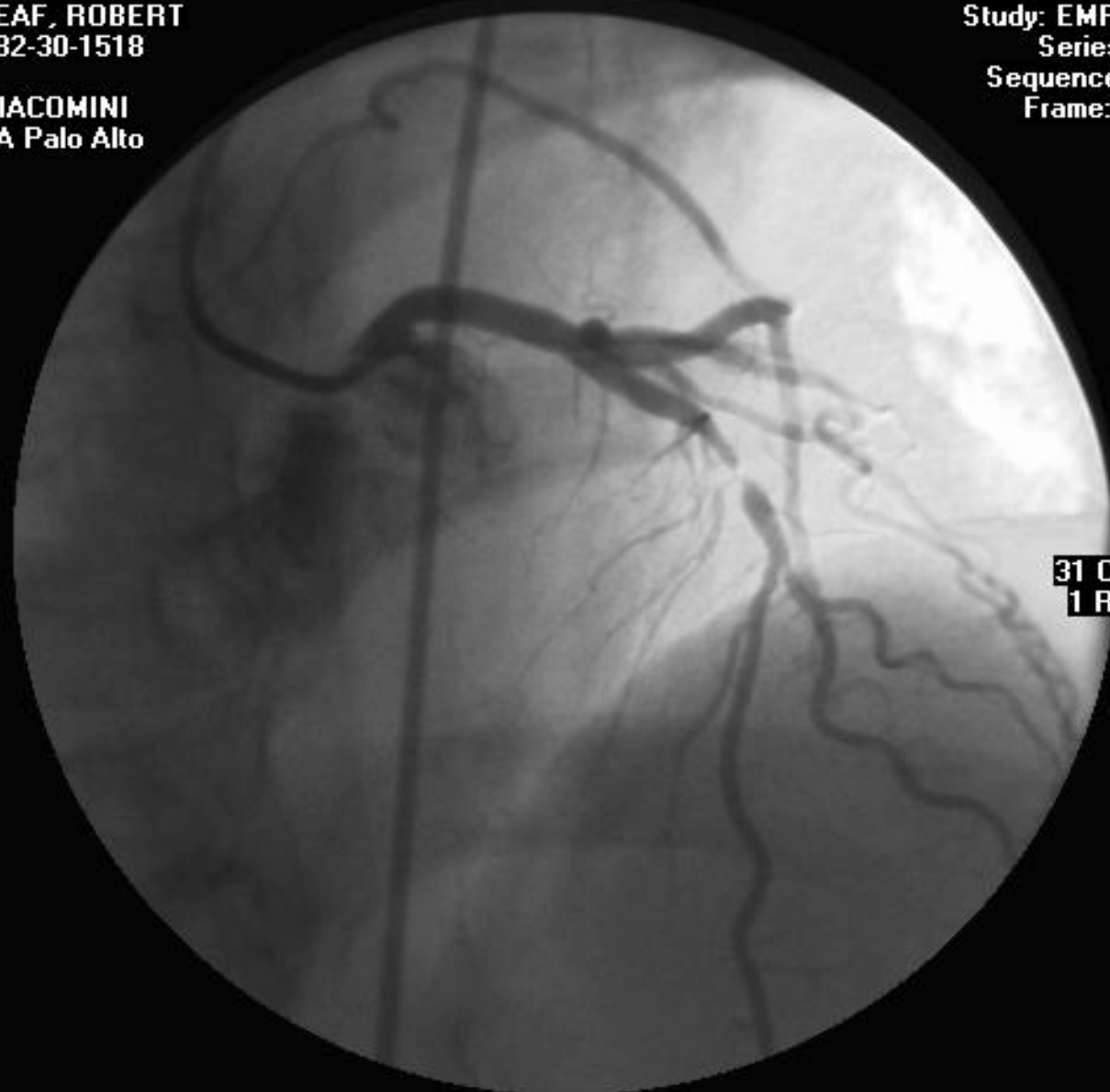
- Rhythms
- ST Segments



LEAF, ROBERT
082-30-1518

GIACOMINI
VA Palo Alto

Study: EMPTY
Series: 1
Sequence: 3
Frame: 47



0 L
31 CRA
1 RAO

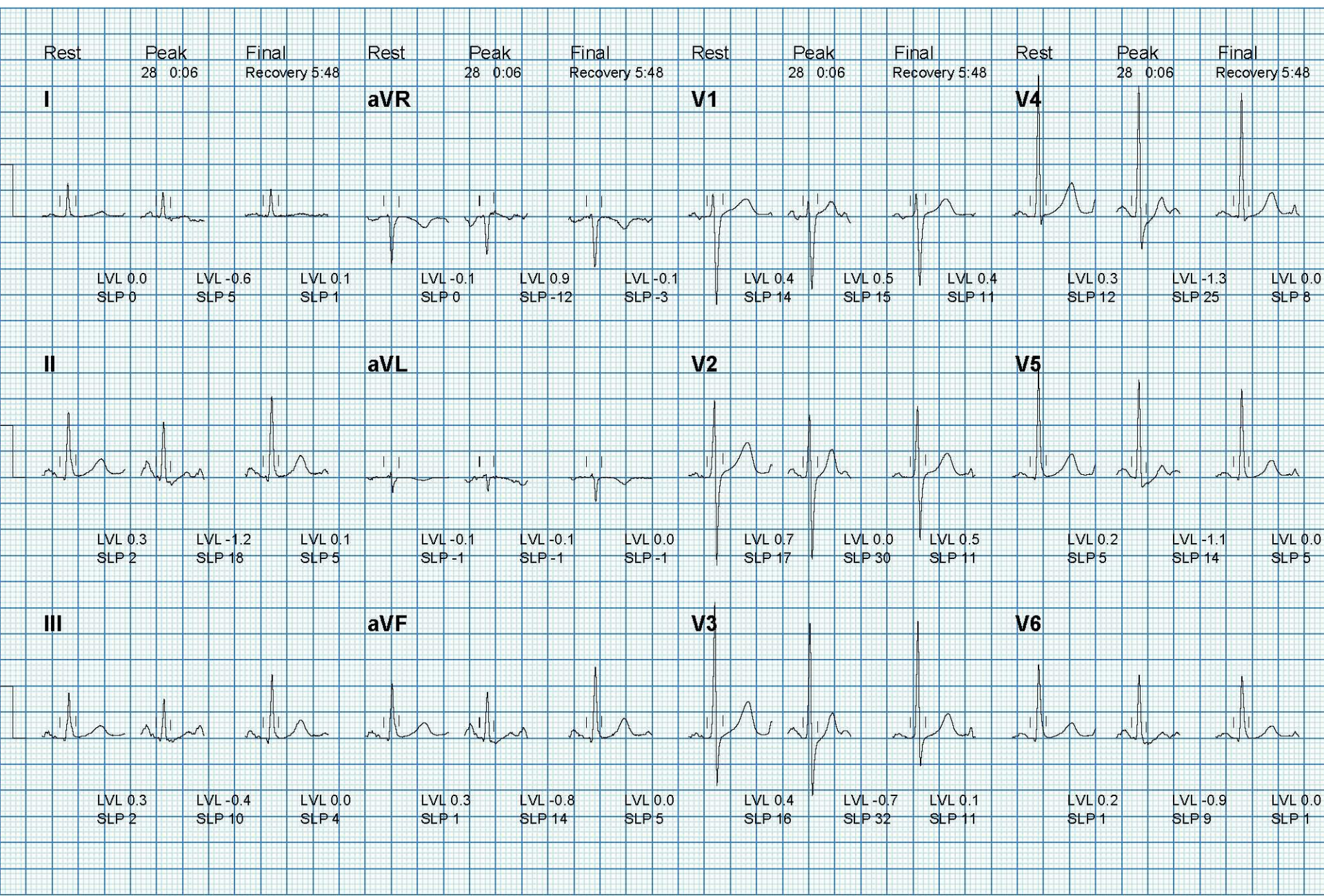
LEAF, ROBERT
082-30-1518

GIACOMINI
VA Palo Alto

Study: EMPTY
Series: 1
Sequence: 19
Frame: 44



0 L
29 CRA
0 LAO

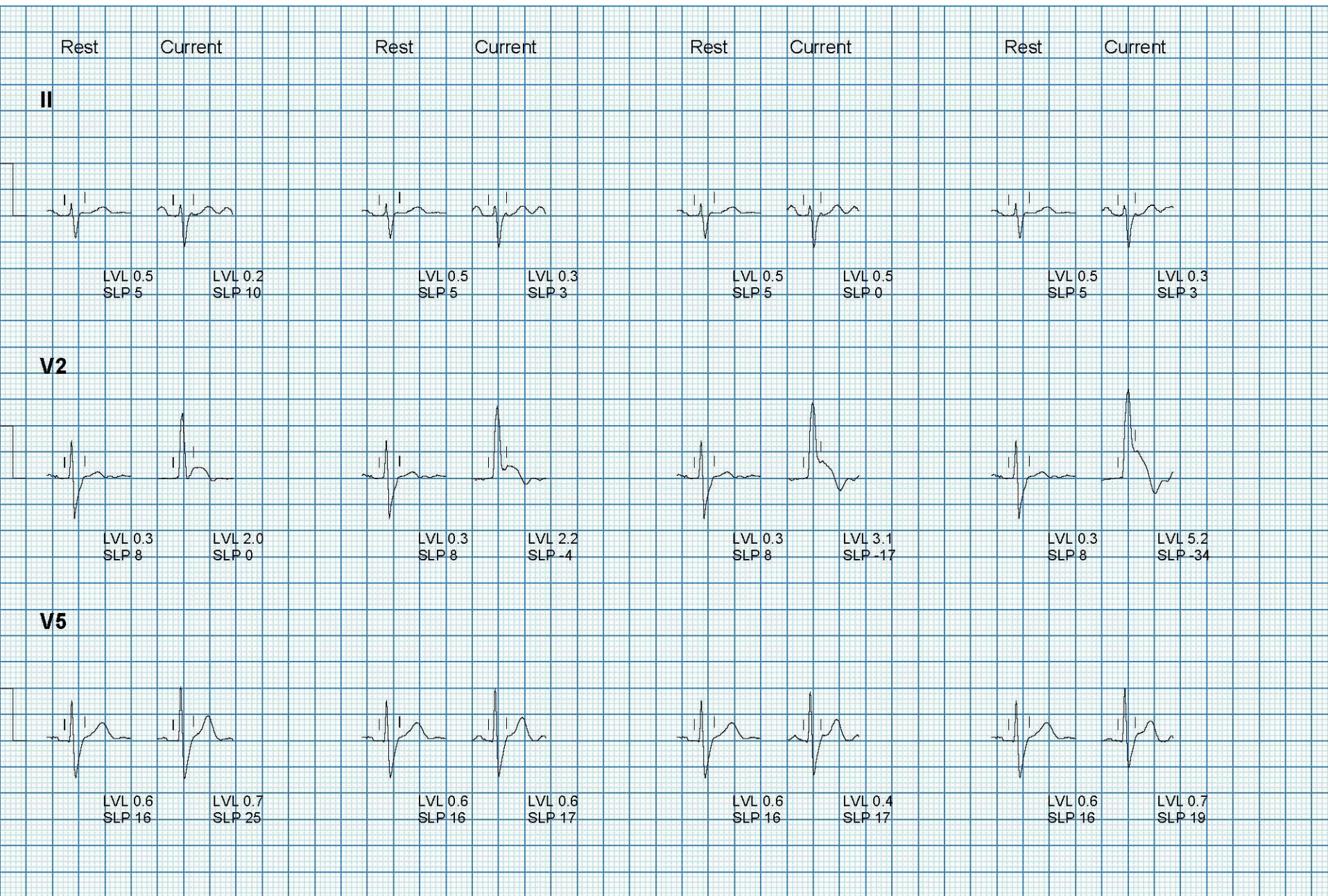


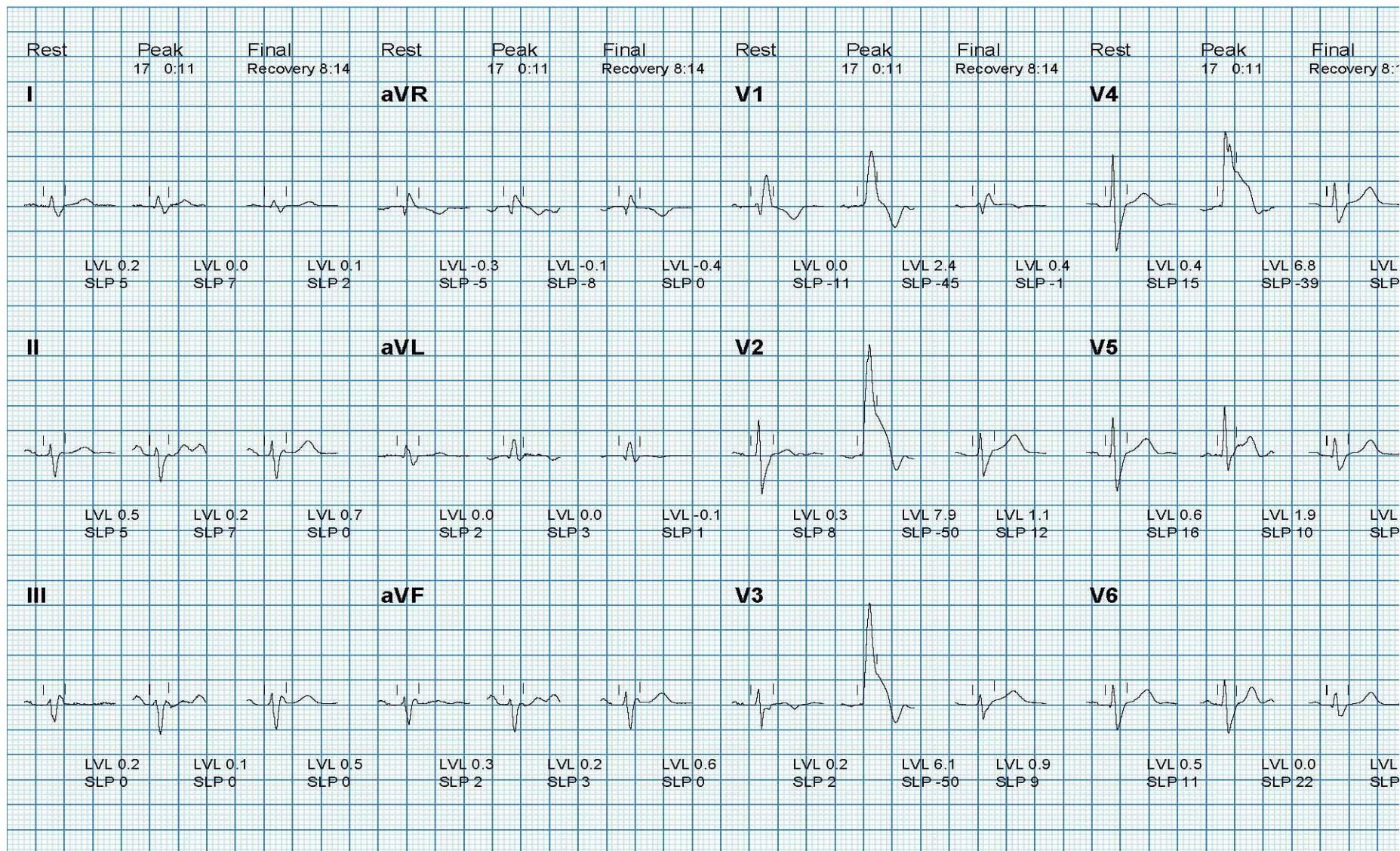
Stage: 9
Time 00:11

Stage: 10
Time 00:11

Stage: 11
Time 00:11

Stage: 12
Time 00:11





aid, Clark, Burgess

597

WILLIAMS
VA Palo Alto

9/19/2008 5:01:03 PM

1000

1

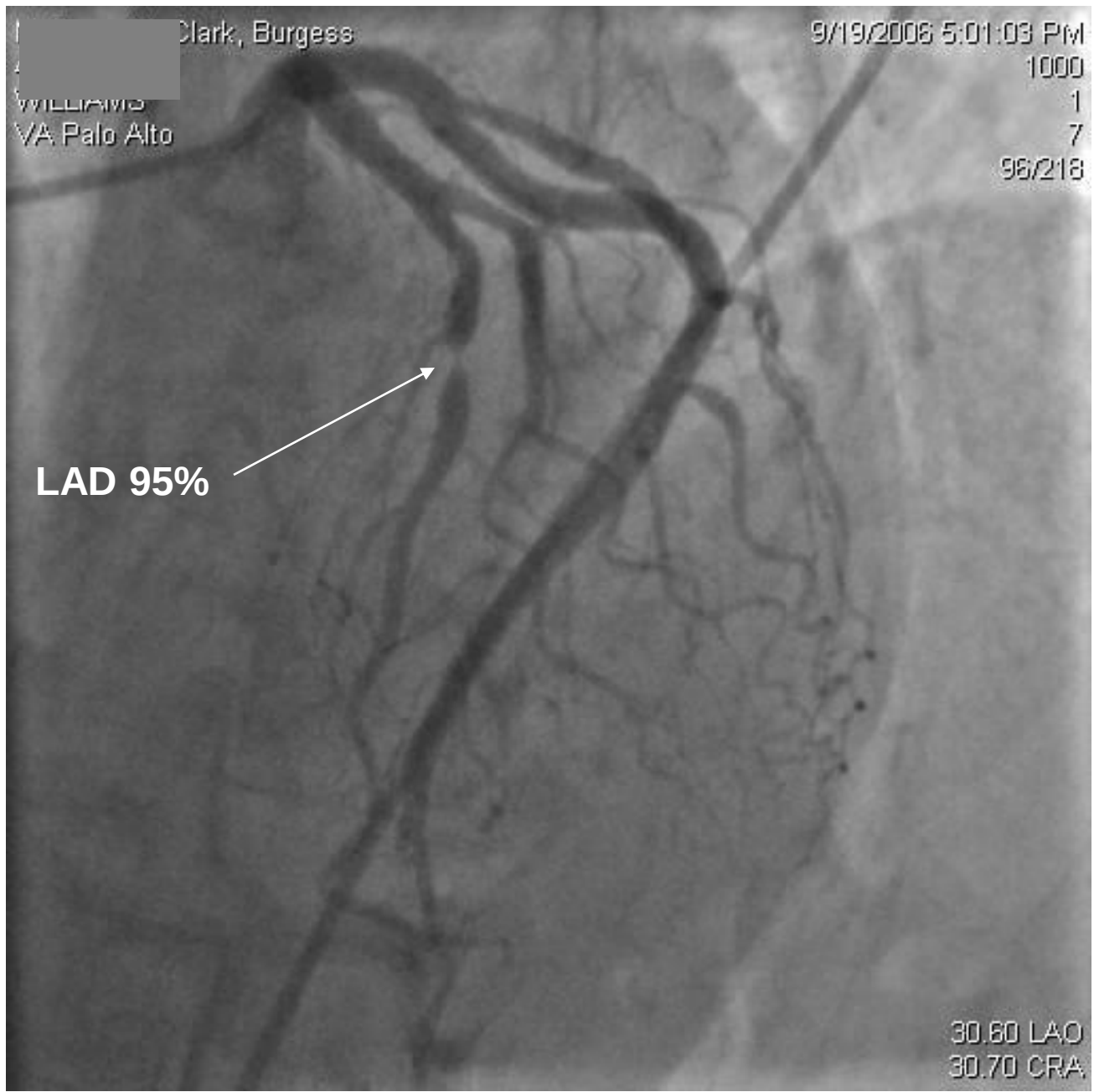
8

103/243

LAD 95%



1.80 RAO
34.10 CRA



Clark, Burgess
WILLIAMS
VA Palo Alto

9/19/2008 5:01:03 PM
1000
1
7
96/218

LAD 95%

30.60 LAO
30.70 CRA

Clark, Burgess

9/19/2008 5:01:03 PM

1000

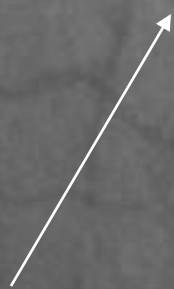
WILLIAMS
VA Palo Alto

1

9

136/229

LAD 95%

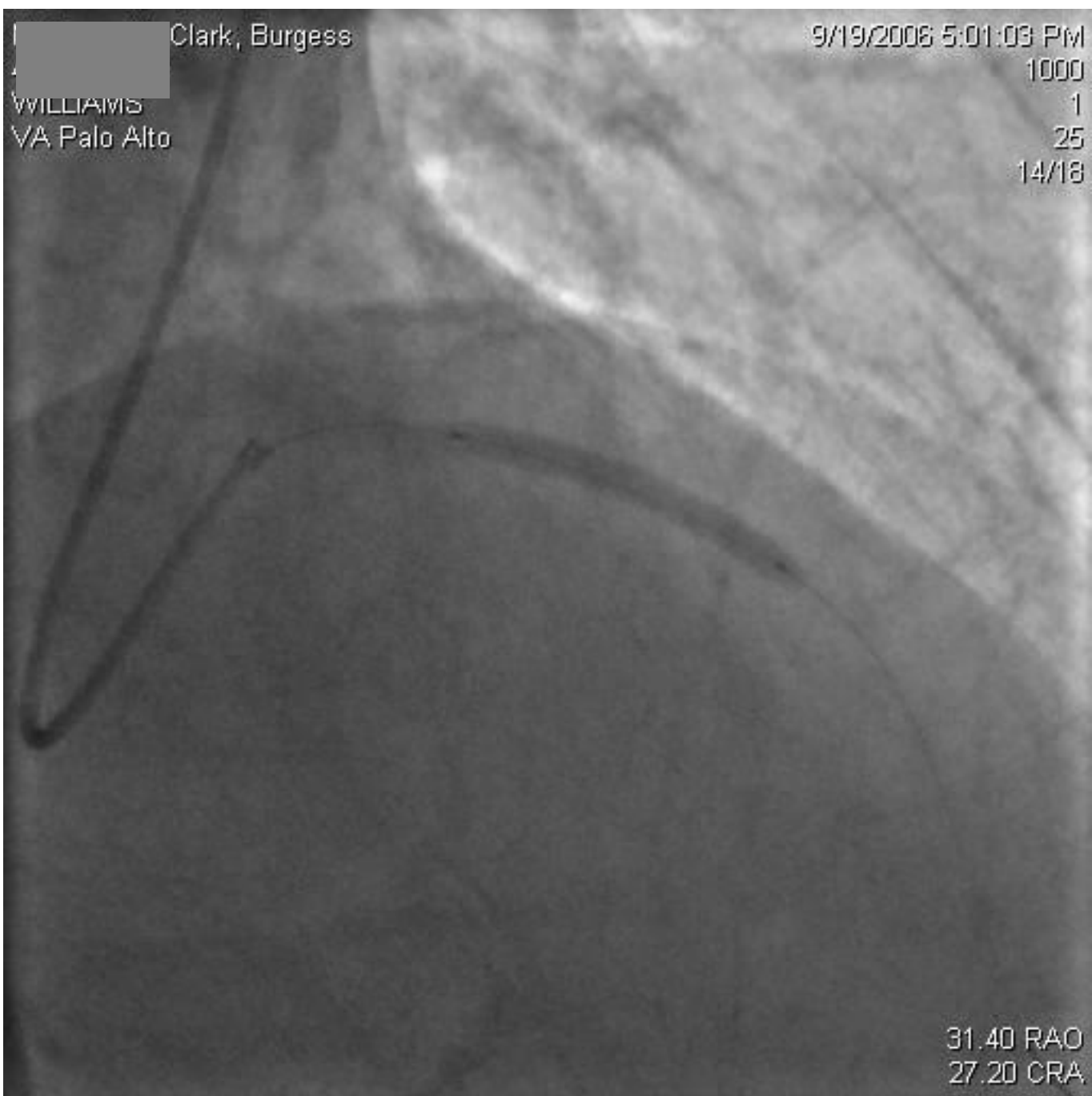


30.30 RAO

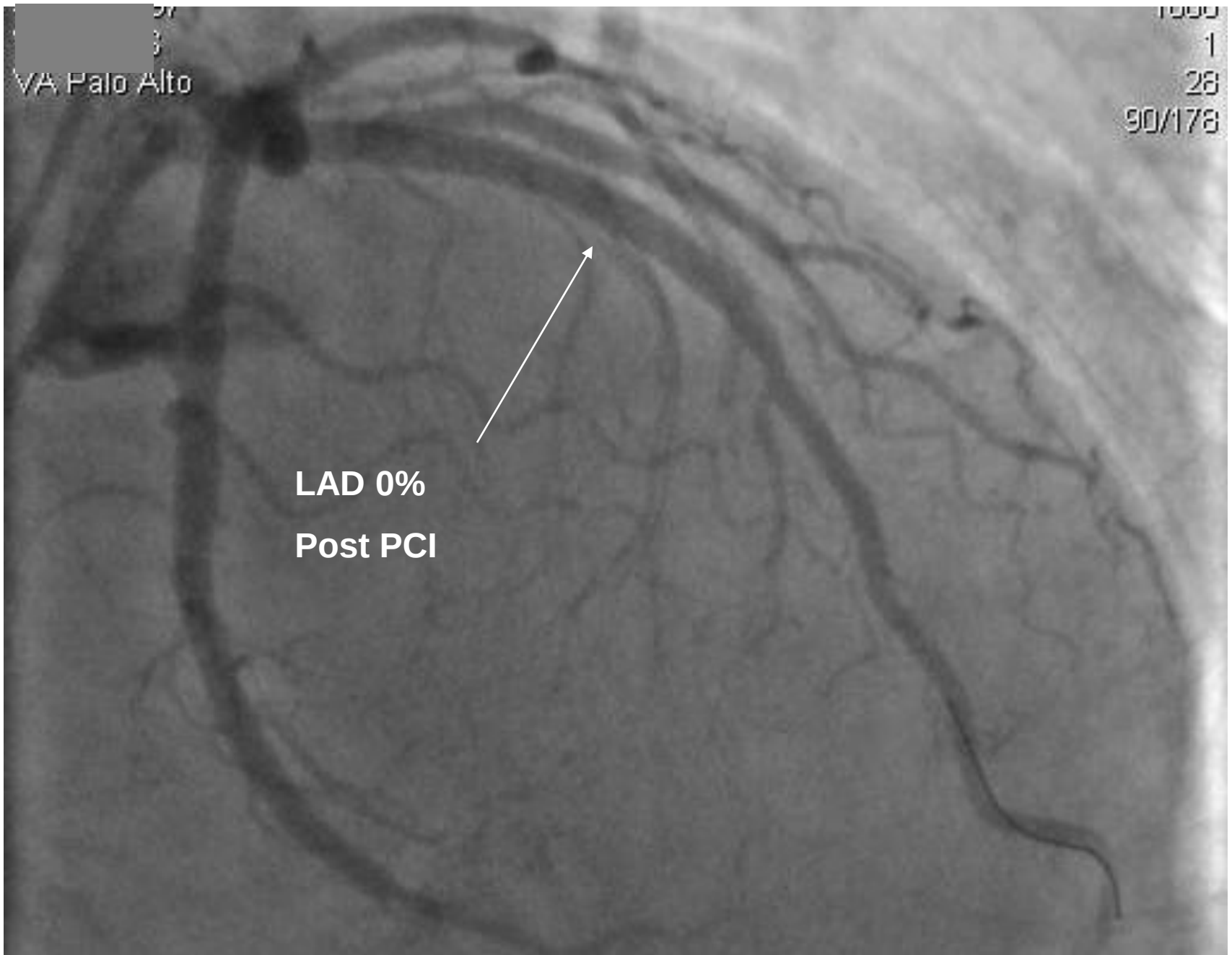
34.10 CRA

Clark, Burgess
WILLIAMS
VA Palo Alto

9/19/2006 5:01:03 PM
1000
1
25
14/16



31.40 RAO
27.20 CRA



37

3

VA Palo Alto

1000

1

28

90/178

LAD 0%

Post PCI

Basic Principles of ECG Interpretation

- ♥ Place electrodes correctly (??)
- ♥ Be Careful to Get Correct Data
- ♥ Consider Clinical Context/Setting
 - ♥ Chest pain? ... consider ST segments
- ♥ Compare to Previous ECG
- ♥ Be Systematic
 - ♥ Rate, Rhythm, ?Pacemaker Spikes
 - ♥ QRS duration, Other intervals
 - ♥ Axis
 - ♥ Q waves
 - ♥ Pattern read

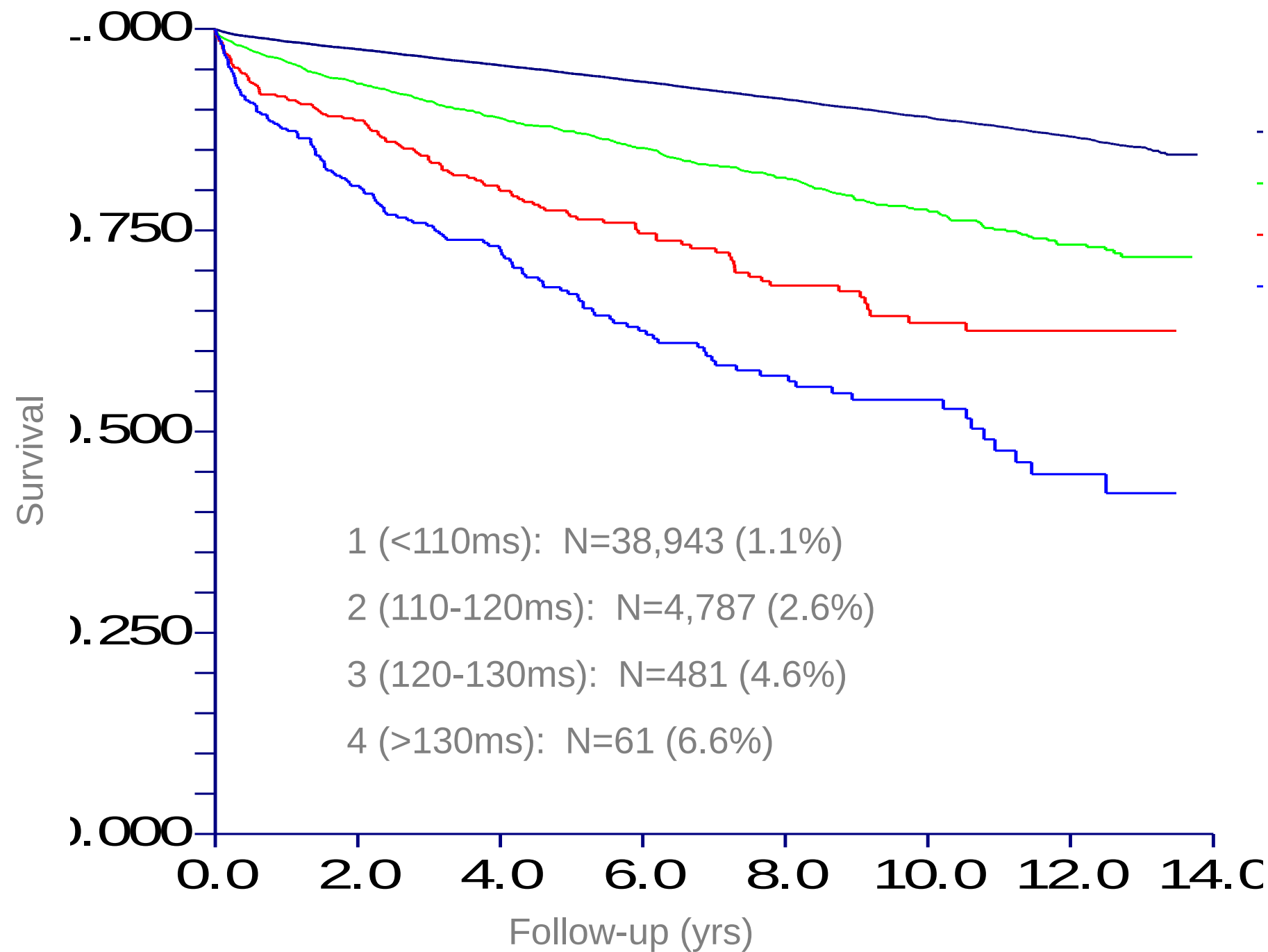
QRS Prolongation

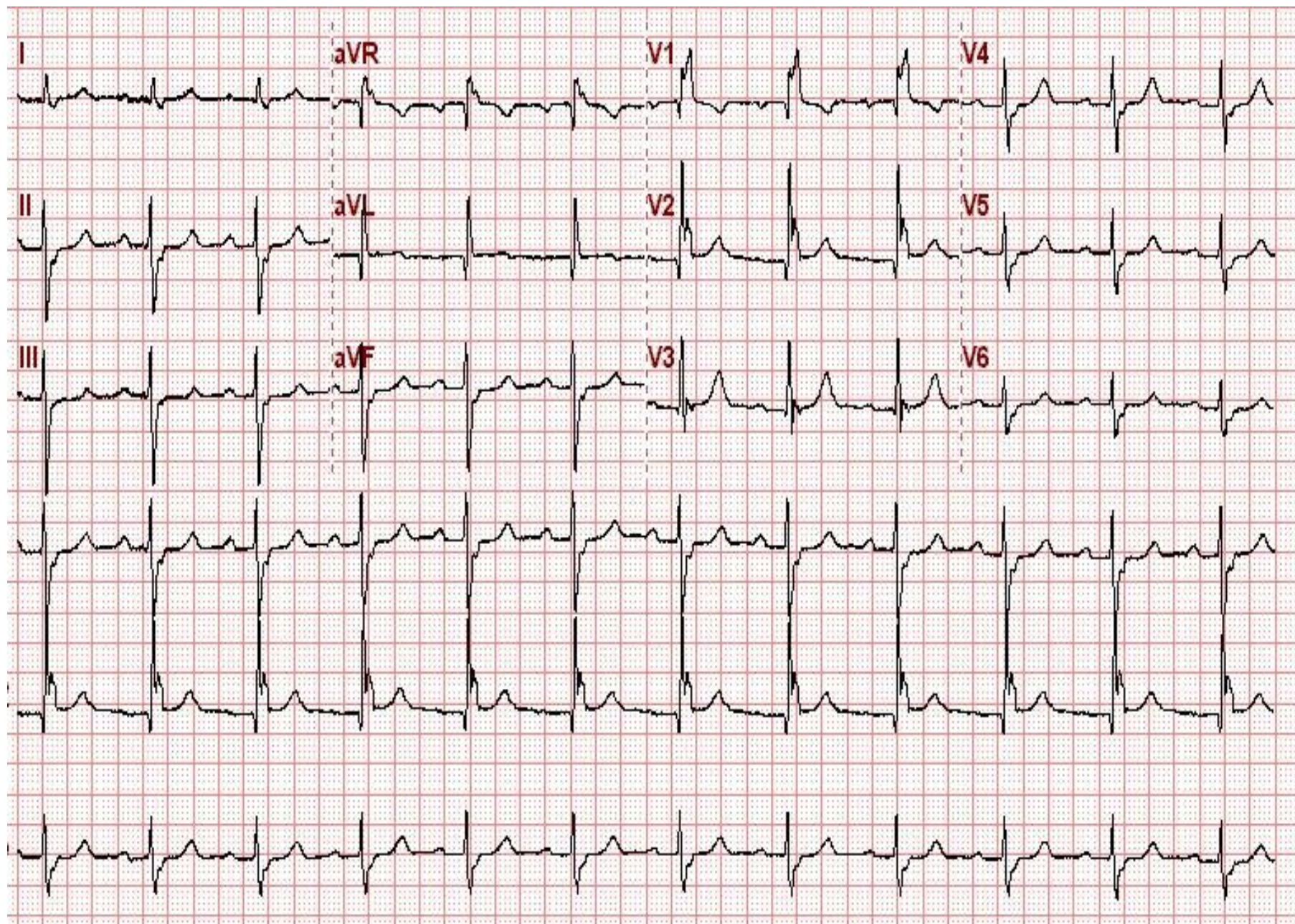
(=>120msec, 3 40 msec boxes)

- ♥ Ventricular Origin
 - ♥ PVCs
 - ♥ Ventricular Tachycardia
 - ♥ Ventricular Electronic Pacemaker
- ♥ SVT with Aberrant Conduction
- ♥ Bundle Branch Block
 - ♥ Right (rabbit ears on the right)
 - ♥ Left (rabbit ears on the left)
- ♥ WPW
- ♥ IntraVentricular Conduction Delay

Why is QRS Prolongation so important except for RBBB???

- ♥ Q waves not diagnostic
- ♥ ST Depression not diagnostic
- ♥ Possibly Ventricular Origin
- ♥ Usually High Risk





Rabbit Ears

I



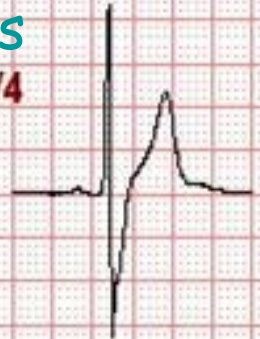
aVR



V1



V4

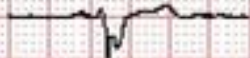


Inverted
Twave

II



aVL



V2



V5



III



aVF

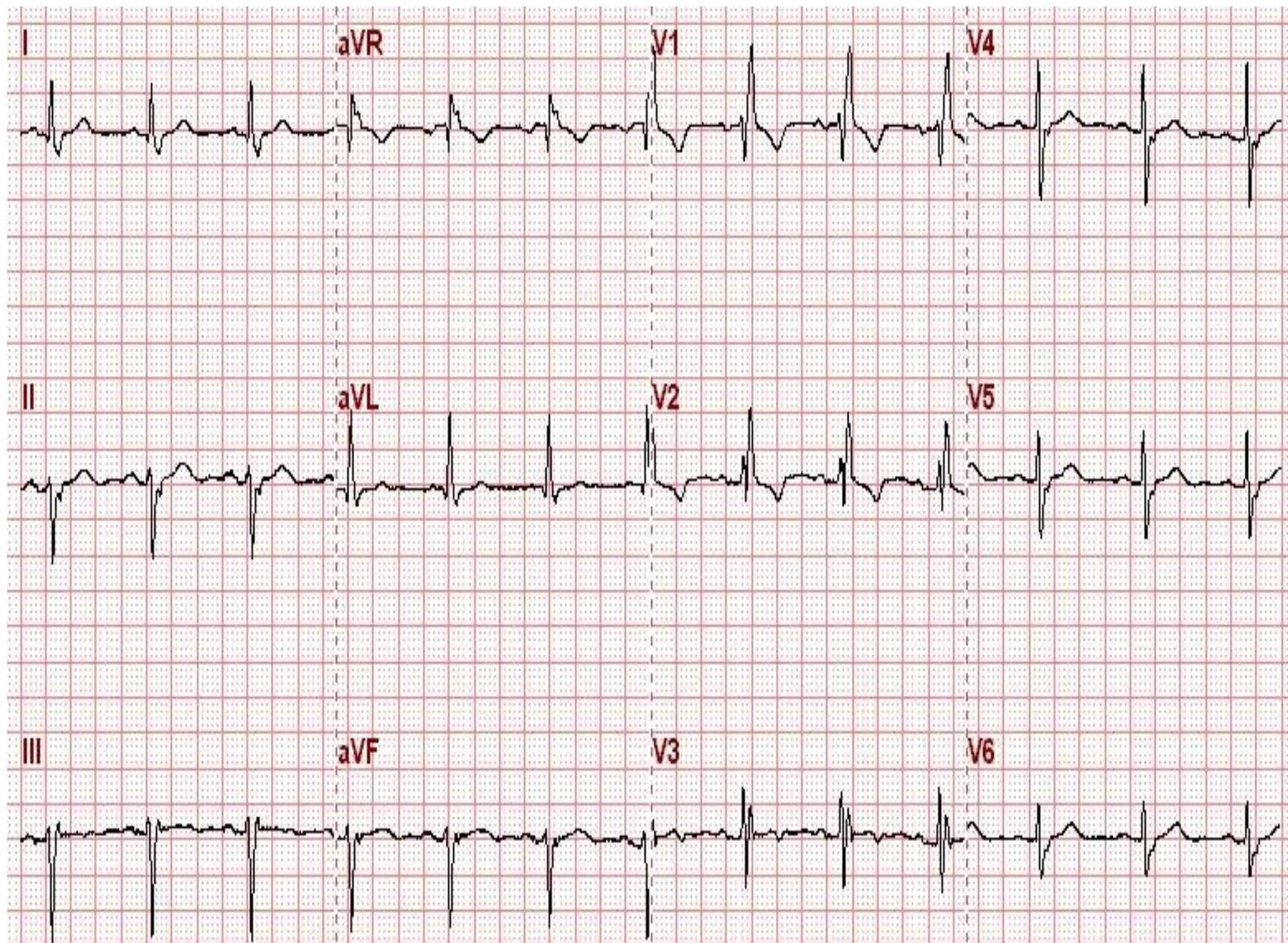


V3



V6





I



5
646
675

aVR



-36
-636
364

V1



21
-1859
114

V4



55
570
870

RBBB

II



63
636
186

aVL



-24
282
980

V2



44
-1301
355

V5



45
698
655

III



59
-4
172

aVF



62
323
158

V3



60
-18
710

V6



34
626
479

aVR



V1



V4



LBBB

aVL



V2



V5



I



aVF

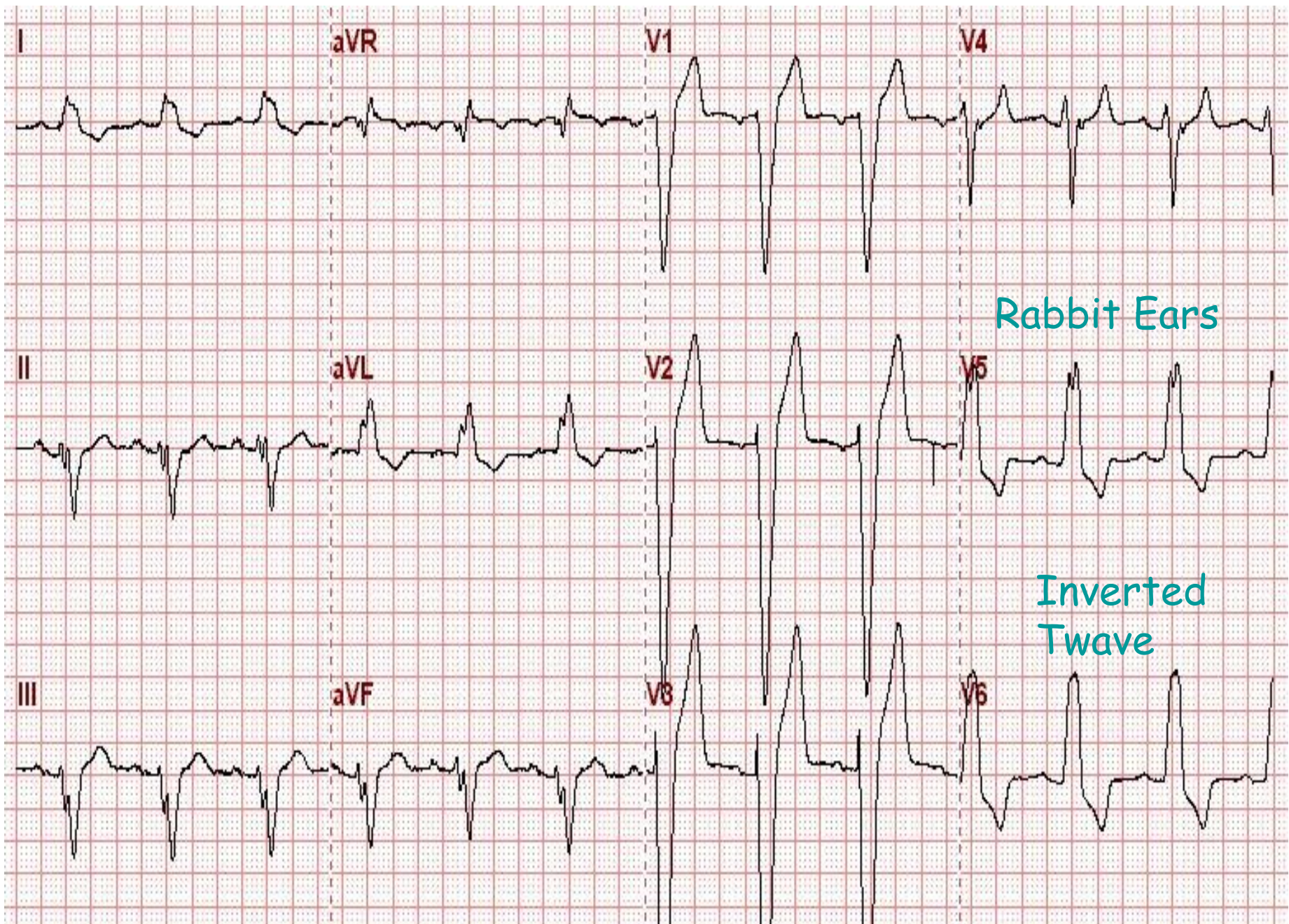


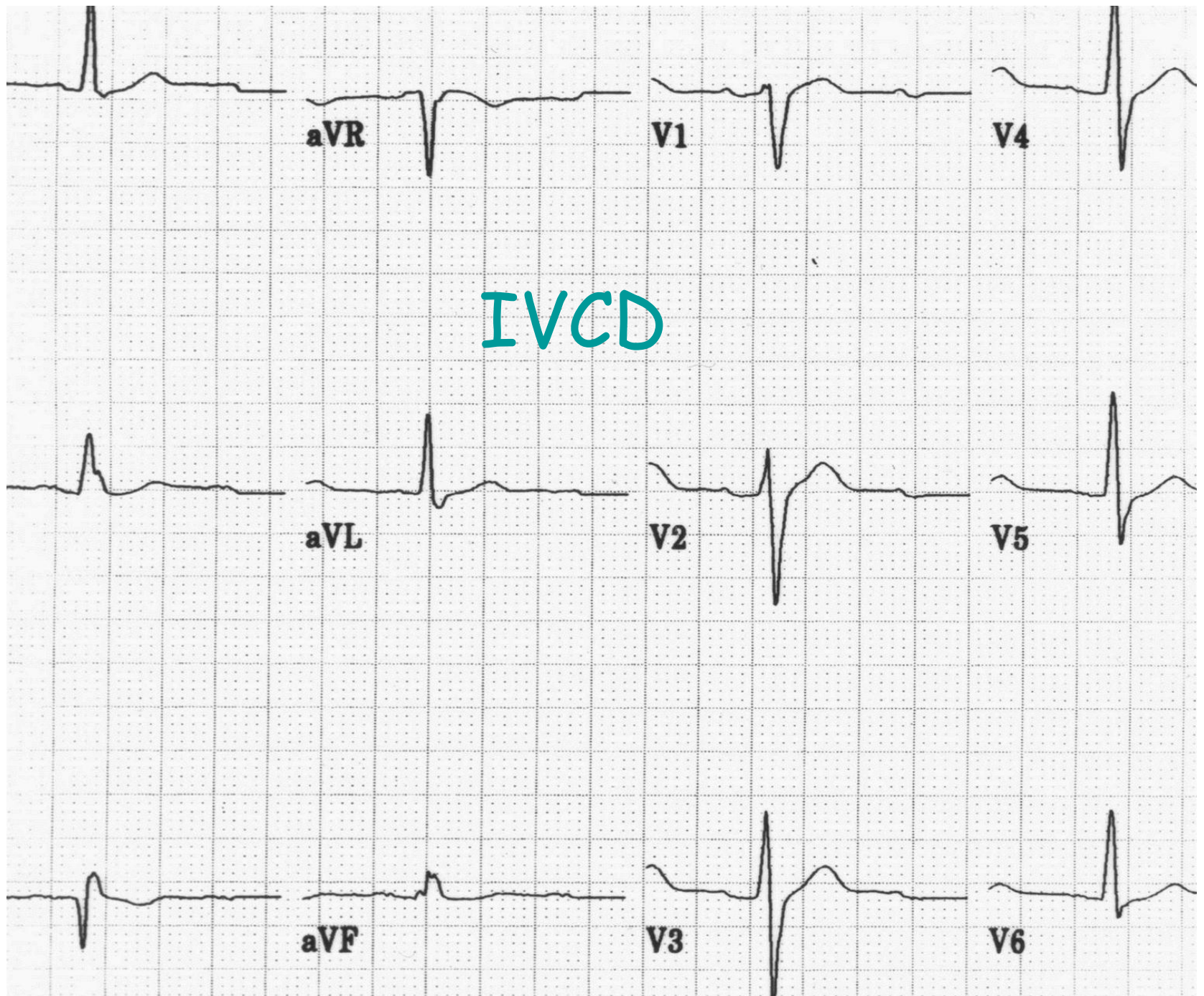
V3

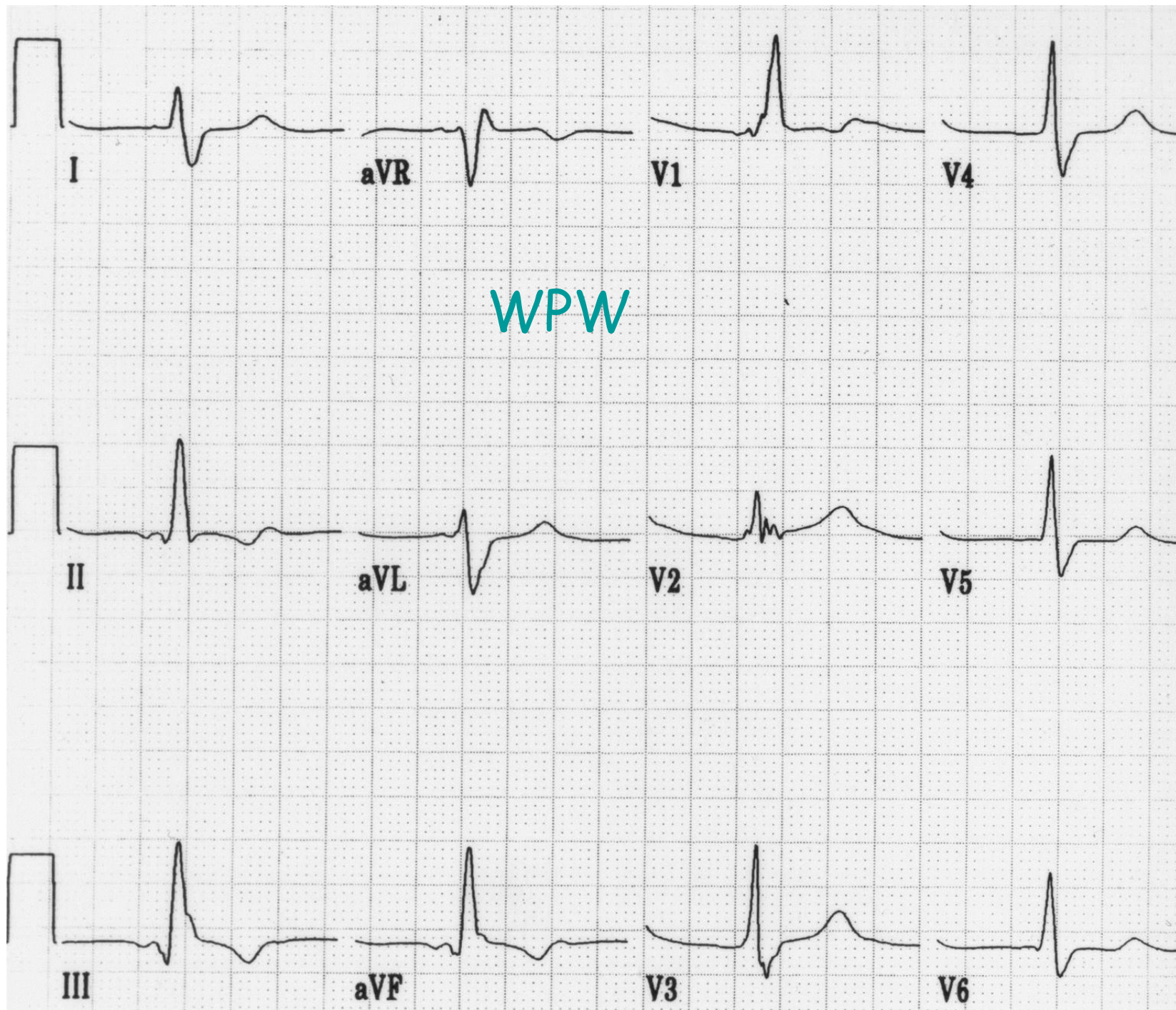


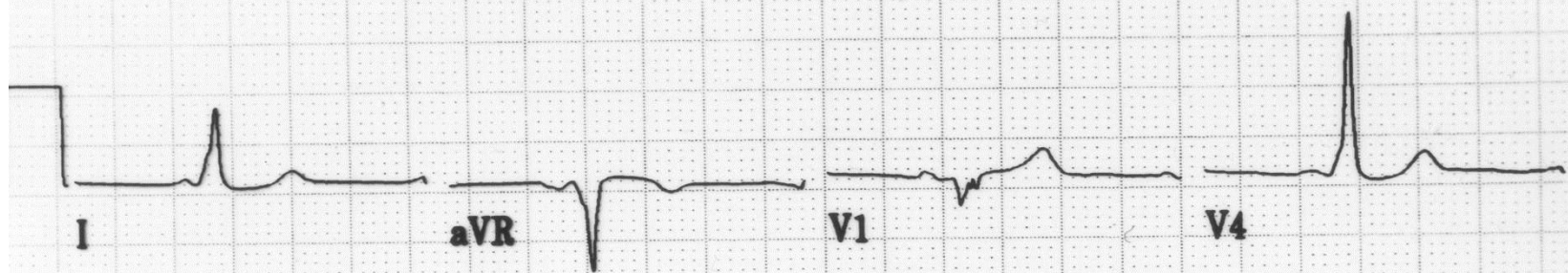
V6



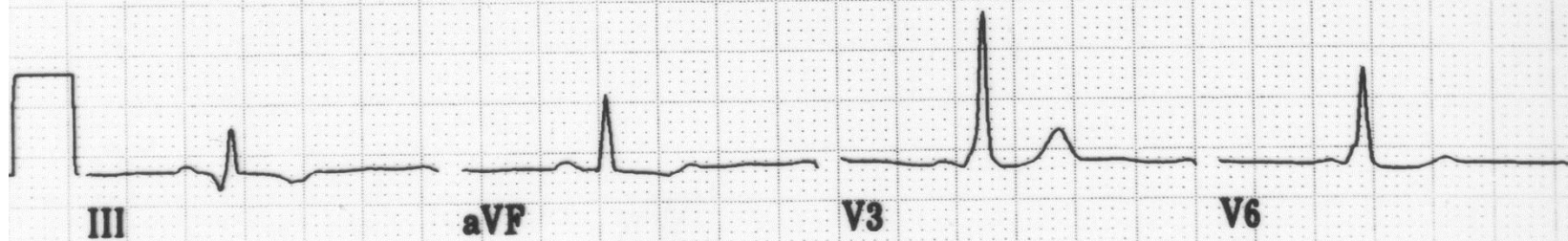
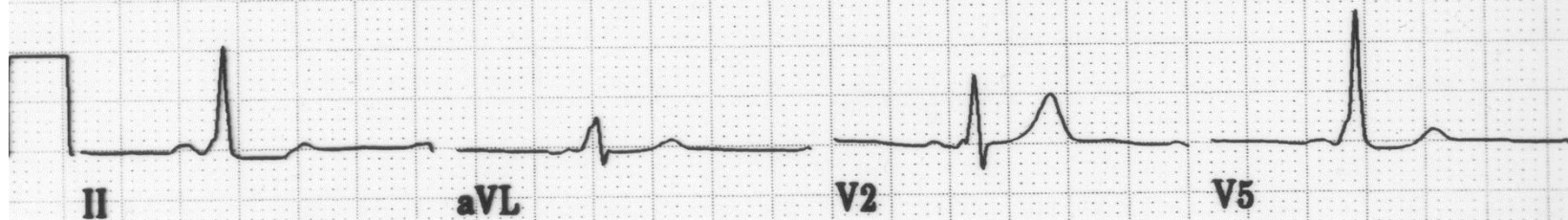


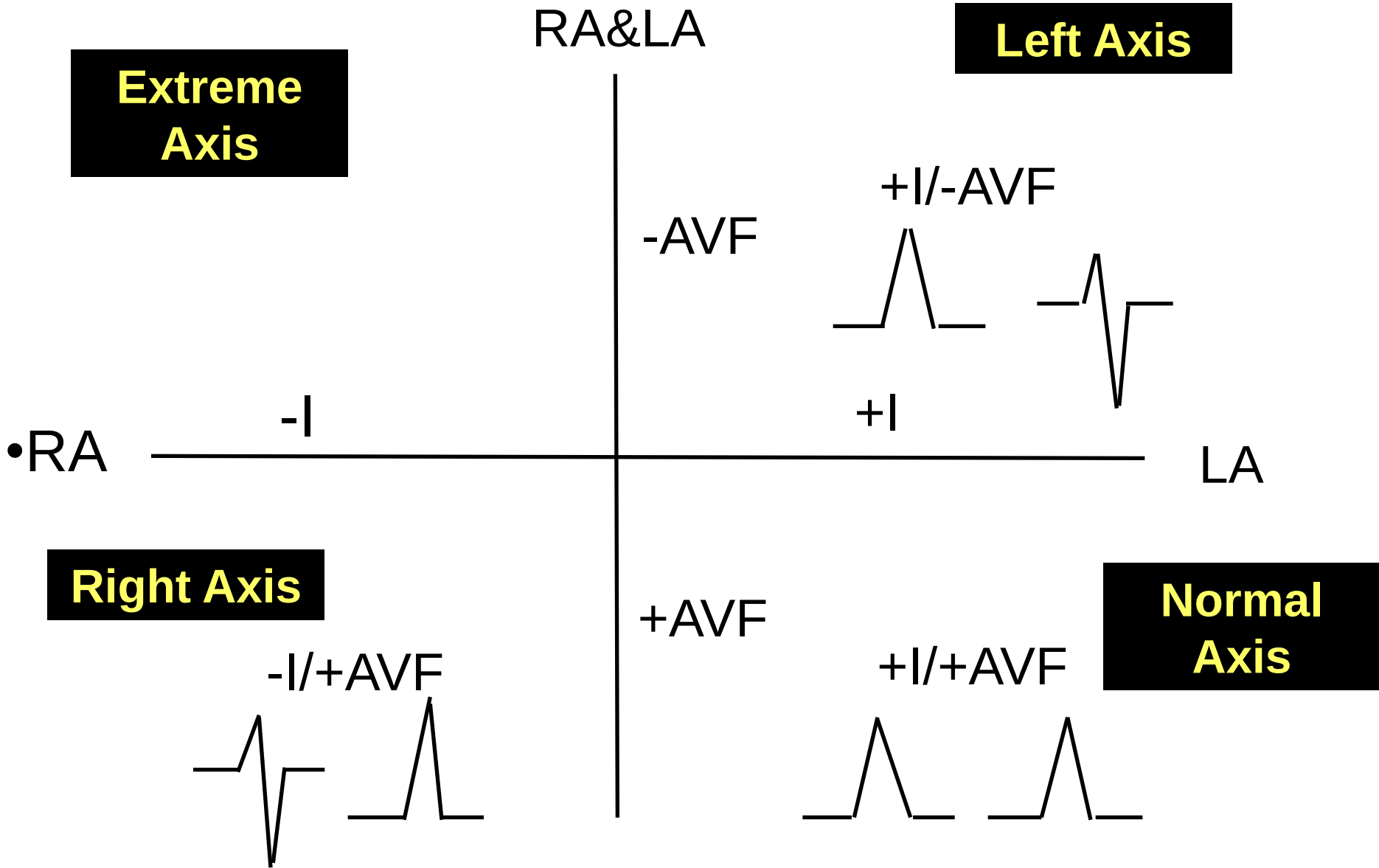


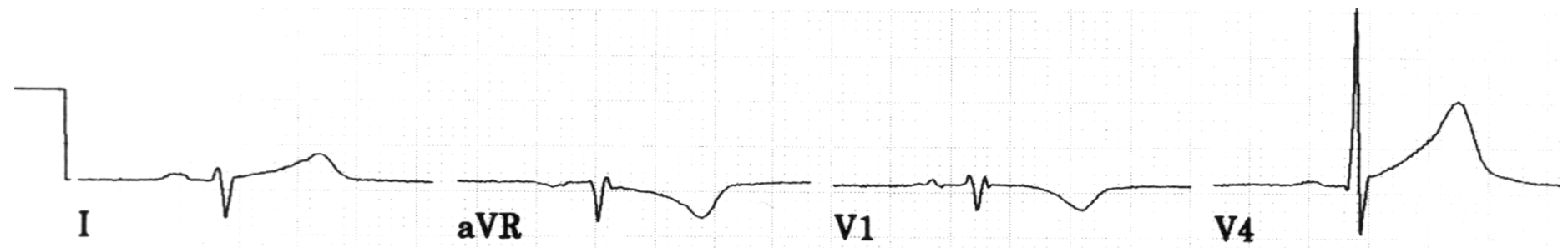




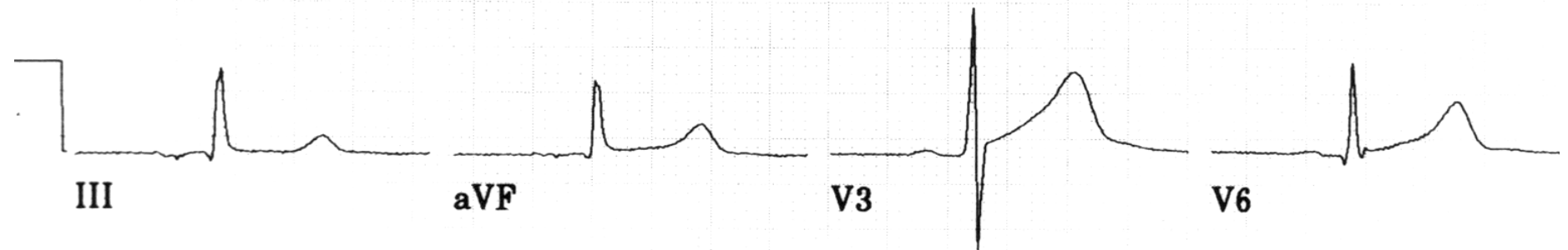
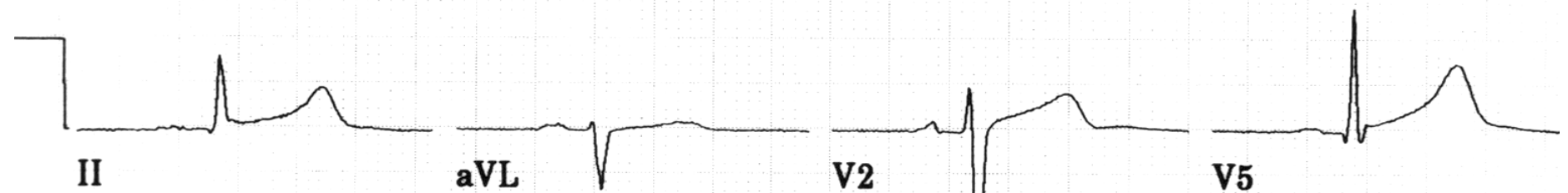
WPW





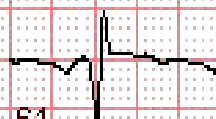


RAD

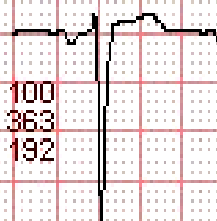


I

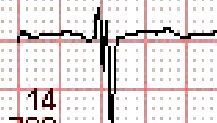
21
91
668

aVR

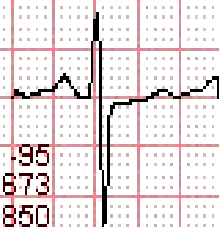
61
258
481

V1

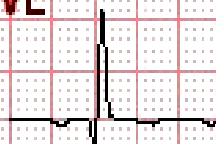
100
363
192

V4

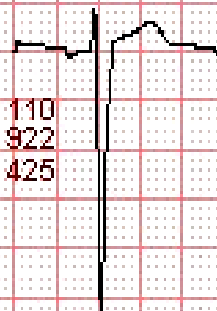
14
780
324

LAD**II**

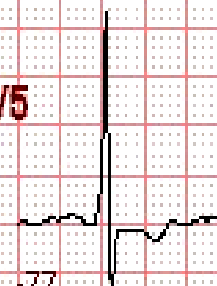
95
673
850

aVL

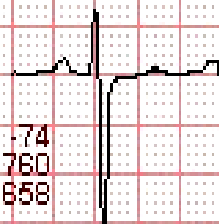
28
419
1108

V2

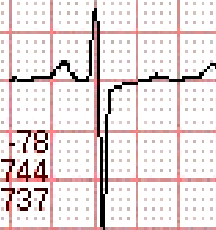
110
922
425

V5

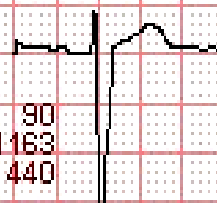
177
202
2162

III

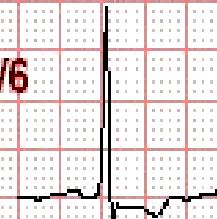
74
760
658

aVF

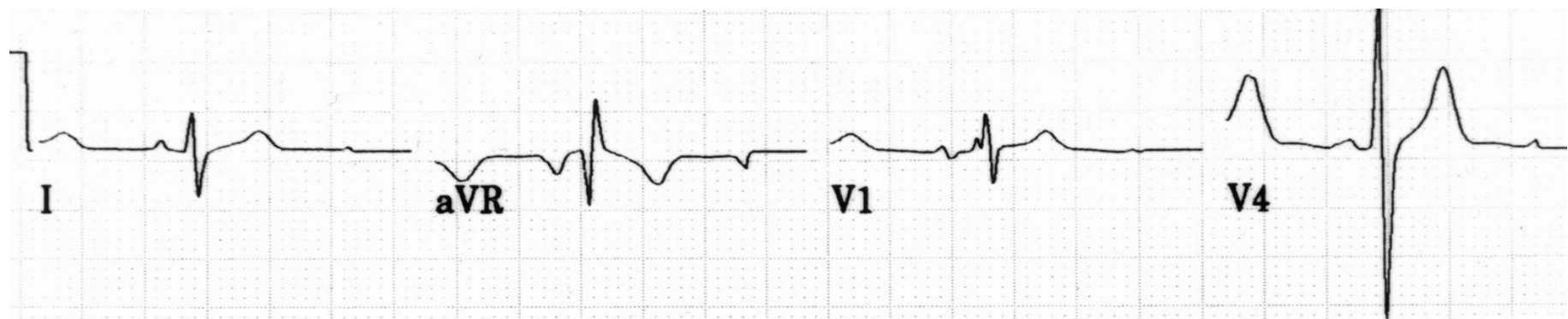
78
744
737

V3

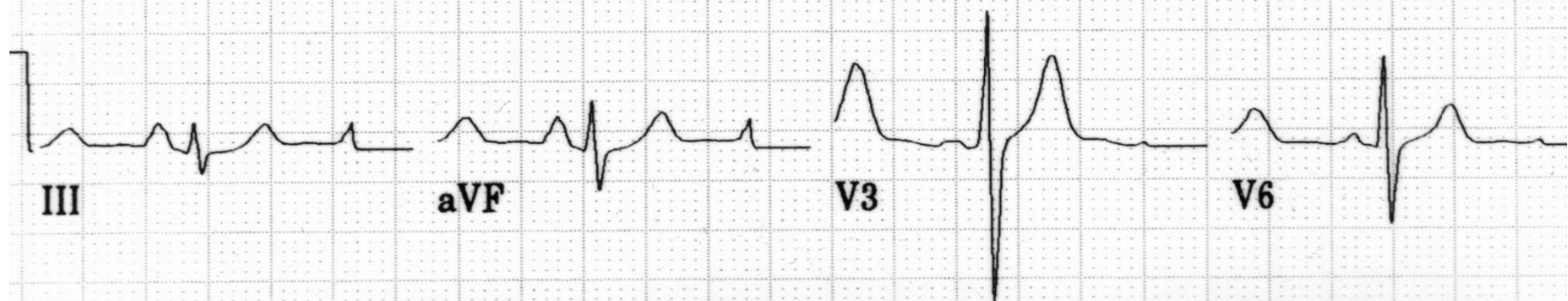
90
1163
440

V6

75
177
1950



S1S2S3

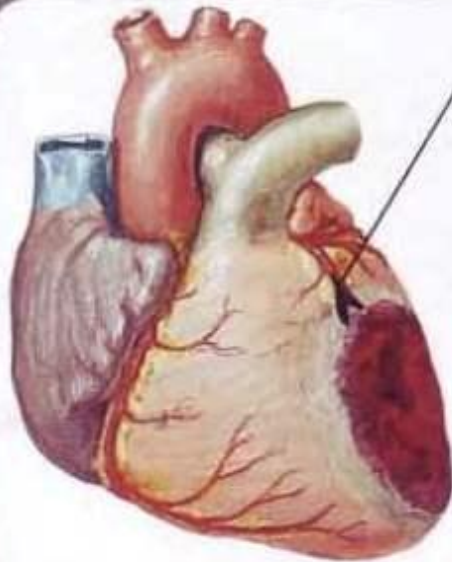


Criteria For Infarction Q Waves

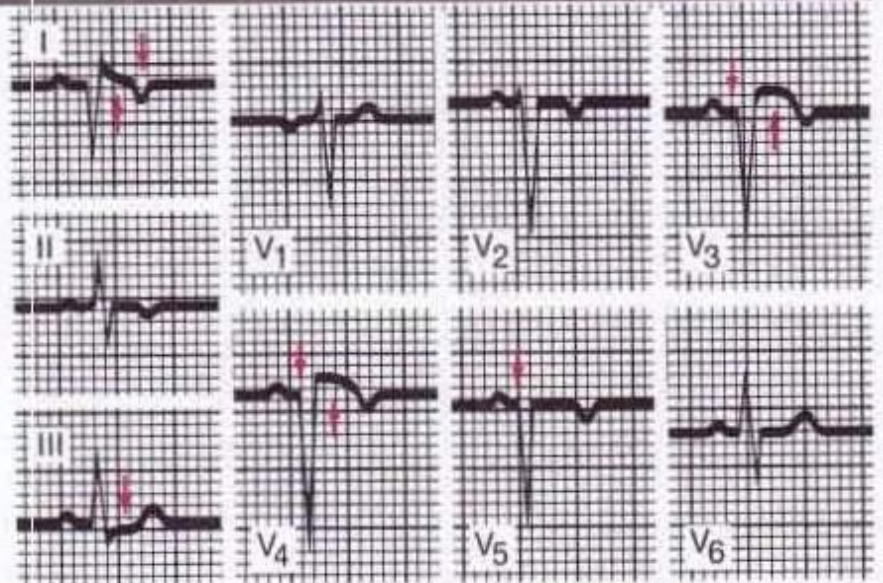
- ♥ Equal or Greater than .04 seconds (one millimeter box horizontal width, 40 milliseconds)
- ♥ Q Wave Amplitude must be 25% or greater of following R Wave
- ♥ Pathophysiology: no muscle to generate R wave

Localization of Anterior Infarcts

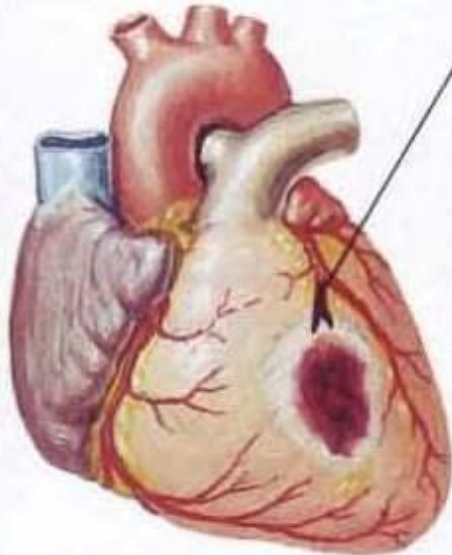
Antero-lateral infarct



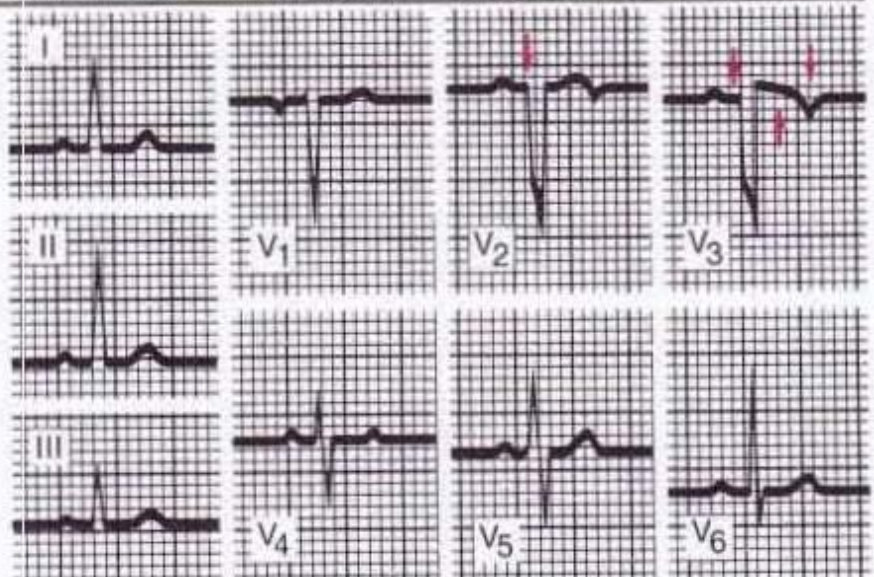
Occlusion of anterior inter-ventricular branch of l. coronary artery



Small, strictly anterior (antero-septal) infarct



Occlusion of r. division of anterior inter-ventricular branch of l. coronary artery

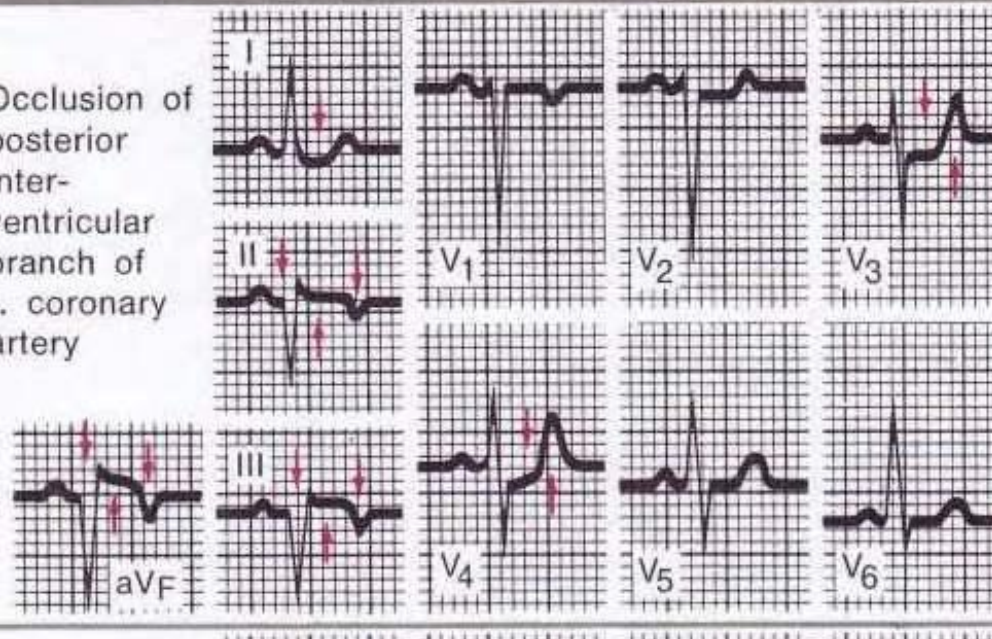


Localization of Posterior Infarcts

Postero-inferior infarct



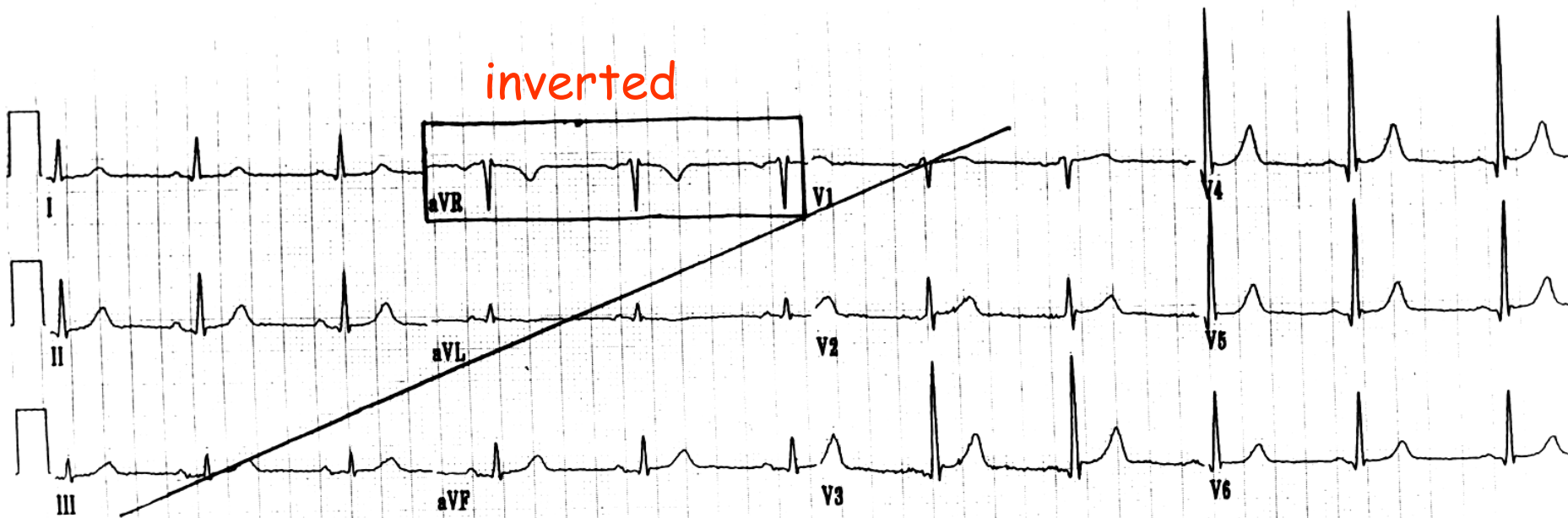
Occlusion of posterior inter-ventricular branch of r. coronary artery



Basic Principles of ECG Interpretation

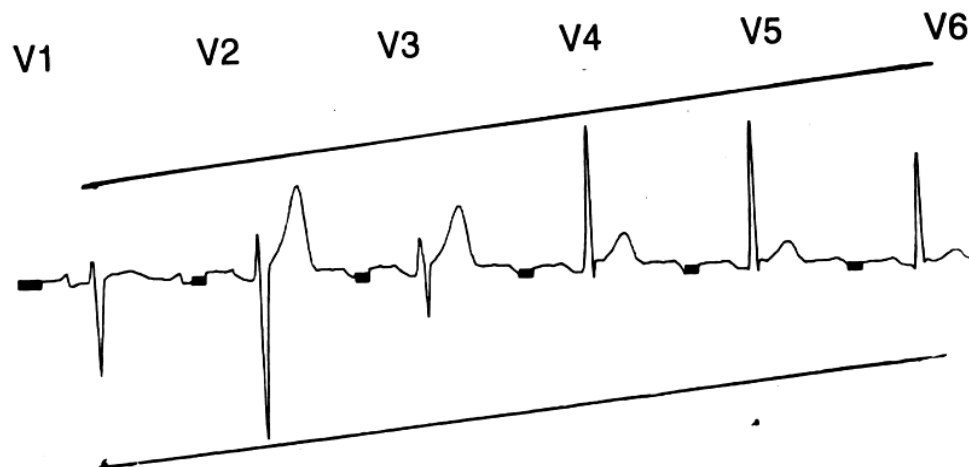
- ♥ Place electrodes correctly (??)
- ♥ Be Careful to Get Correct Data
- ♥ Consider Clinical Context/Setting
 - ♥ Chest pain? ... consider ST segments
- ♥ Compare to Previous ECG
- ♥ Be Systematic
 - ♥ Rate, Rhythm, ?Pacemaker Spikes
 - ♥ QRS duration, Other intervals
 - ♥ Axis
 - ♥ Q waves
 - ♥ Pattern read

DIAGONAL RULE



Qw, P/T
up or
down

PARALLEL LINE RULE (R-WAVE PROGRESSION)



Right
ventricular
involvement:
RVH, RBBB

Left ventricular
involvement:
LVH, LBBB

Pattern Reading of the ECG

♥ Diagonal Line Rule

- ♥ box around aVR (everything inverted)
- ♥ line thru III, aVL, V1
- ♥ every thing else upright

♥ Parallel Line Rule

- ♥ R waves increase then drop off in V6
- ♥ S waves decrease from greatest in V1
- ♥ Rabbit ears on right side (V1-2) for RBBB, on left side for LBBB

The 5 Commandments of ECG Interpretation

- Be systematic
- Put into the clinical context
- Find an old ECG

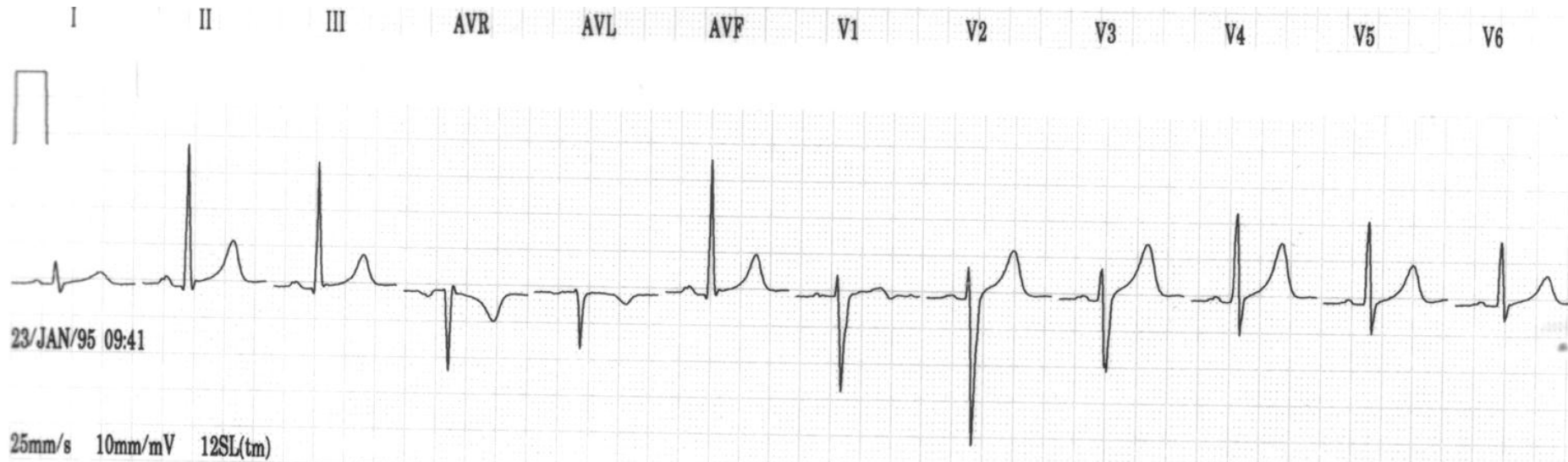
Watch out for bad data

- Do NOT be afraid to get help

Watch for bad data!!



“Wait! Wait! ... Cancel that, I guess it says ‘helf.’”



RA/LA reversed



V1/V3 reversed



I II III AVR AVL AVF V1 V2 V3 V4 V5 V6



What happened?



Basic Principles of ECG Interpretation

♥ Be Systematic

- ♥ Rate: Fast-Normal-Slow
- ♥ Rhythm: Sinus, Blocks, Atrial, Ventricular
- ♥ Axis: Normal, Right, Left
- ♥ Intervals and Durations

**Intervals and Durations:
Short ? Long ?**

5 mm
0.2 second

1 mm
0.04 second

5 mm
0.5 mV

PR segment

ST segment

P

Q

R

S

T

U

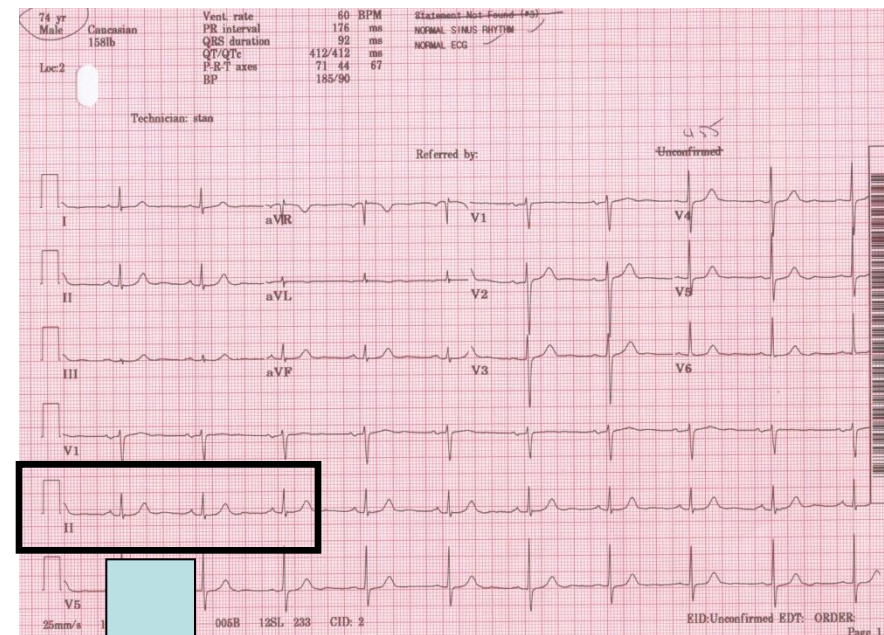
PR interval

QRS interval

QT interval

Intervals

- PR Interval
- QRS Duration
- QT Interval



PR interval

Normal: .12-.20 sec
(3-5 small boxes)

QRS duration

Normal: .07-
.10 sec

QT Interval

Normal (corrected for
rate or QTc): .440-.470
sec

Intervals: Conduction System Abnormalities

- ♥ Congenital Syndromes
- ♥ Electrolyte/Metabolic Abnormalities
- ♥ Intrinsic Cardiac Disease
- ♥ Medications
- ♥ CNS Disorders
- ♥ Systemic Illnesses

Electrolyte Abnormalities and the ECG

♥ Potassium

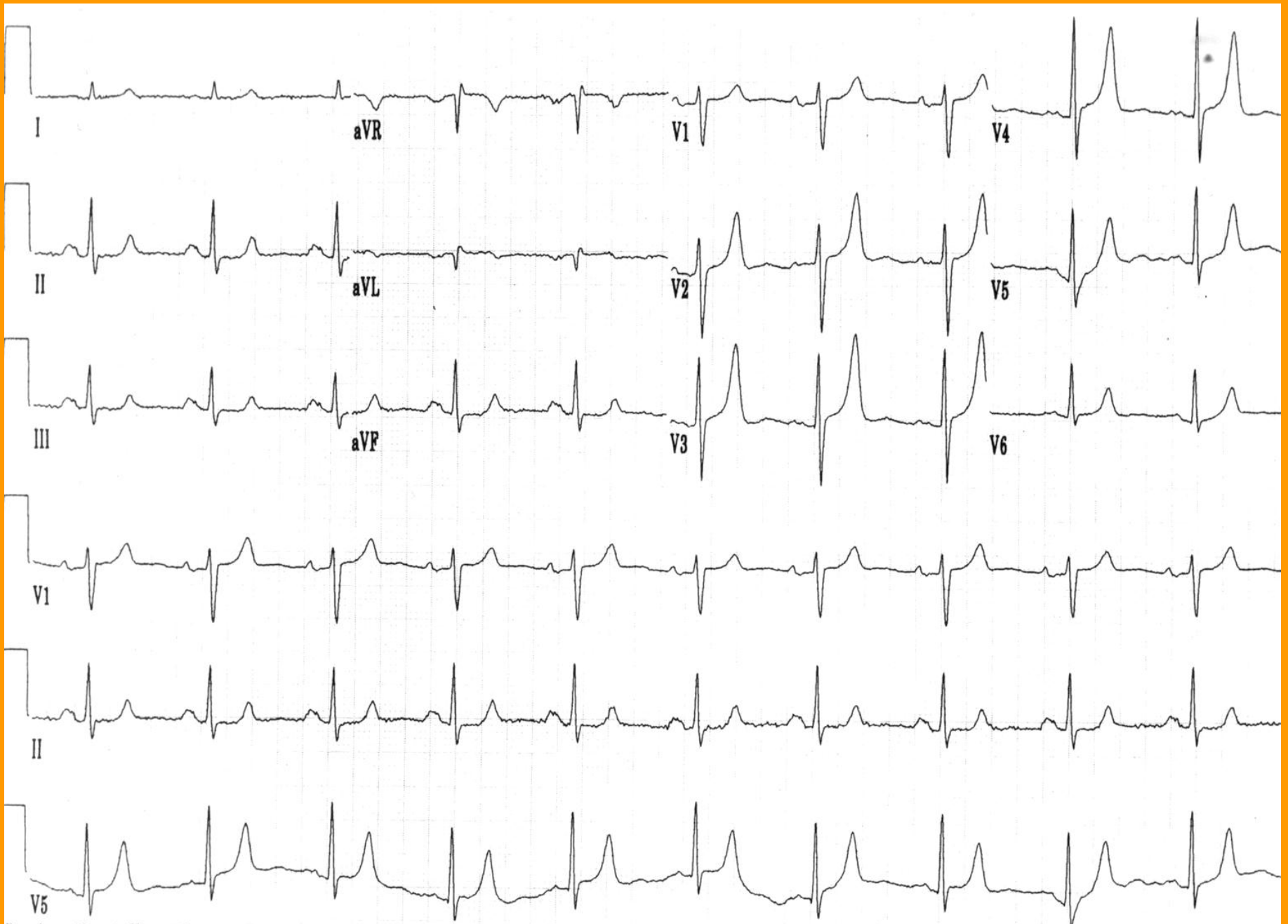
- ♥ Hyper: tall, peaked T waves (also ischemia), atrial arrest
- ♥ Hypo: prominent U waves, low T wave

♥ Calcium

- ♥ Hyper: short QT
- ♥ Hypo: long QT (also Quinidine, ischemia)

♥ Magnesium

- ♥ Hyper: short QT interval
- ♥ Hypo: long QT interval



Long QT intervals

(>50% of the RR interval)

- Congenital
 - HypoMg/CA
 - anti-arrhythmics
 - Myocarditis
 - Hypokalemia
- Ischemia
 - Phenothiazines
 - Tricyclics
 - CNS--Subarachnoid Hemorrhage
 - Torsades des Pointes

The QT interval

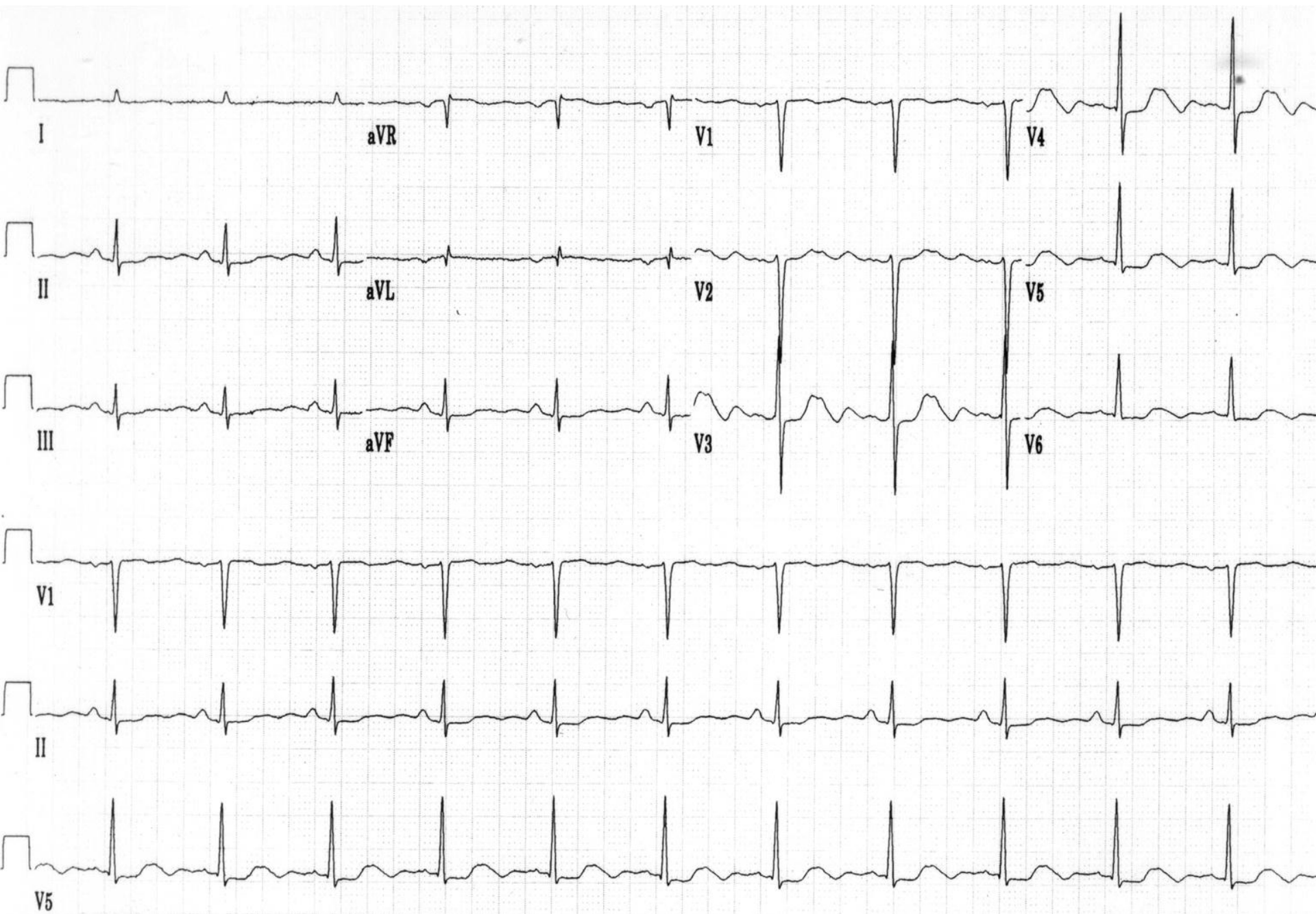
♥ Long QT

(>50% of the RR interval)

- ♥ Congenital
- ♥ Hypomagnesium
- ♥ Hypocalcemia
- ♥ IA anti-arrhythmics
- ♥ Ischemia
- ♥ Torsades de Pointes
- ♥ Phenothiazines
- ♥ Tricyclics
- ♥ Myocarditis
- ♥ Hypokalemia

♥ Short QT

- ♥ Hypercalcemia
- ♥ Hypermagnesium
- ♥ Hyperkalemia
- ♥ Digoxin
- ♥ Thyrotoxicosis

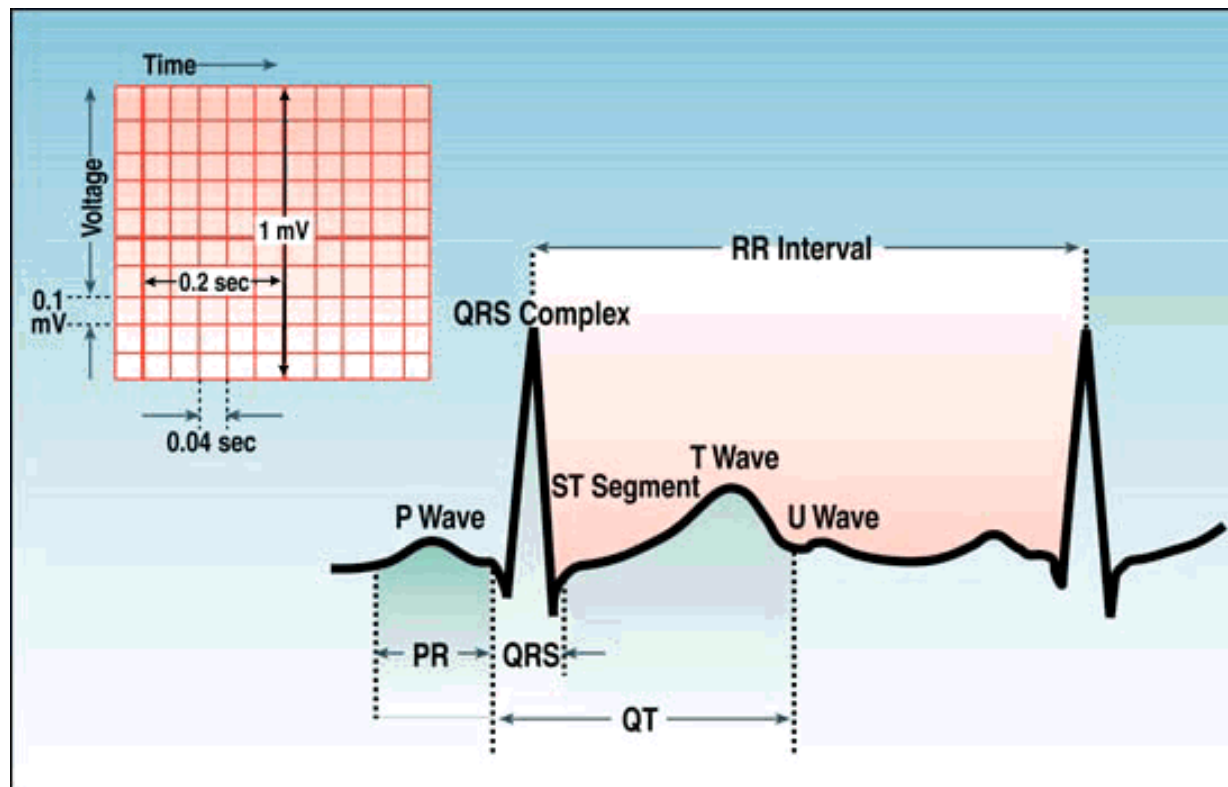




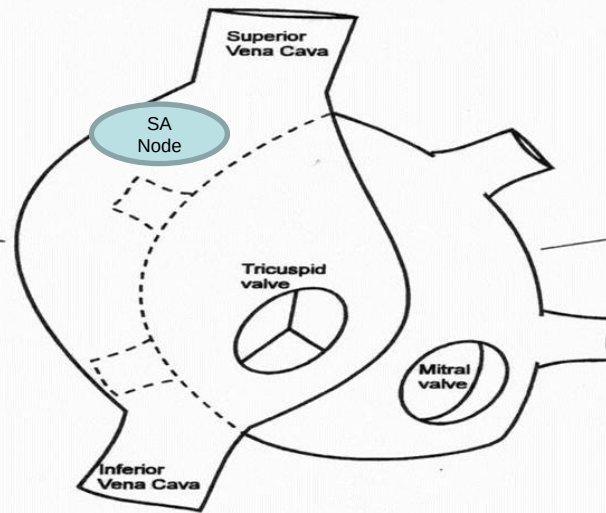
"Mr. Osborne, may I be excused? My brain is full."

Other Patterns

- Atrial Abnormalities
- $R > S$ V1



Right Atrium



Left Atrium

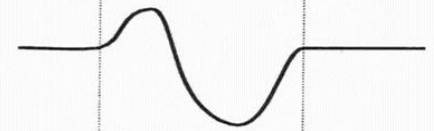
II/aVF

V₁

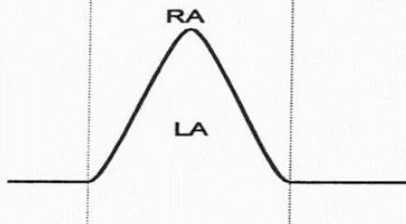
Normal



Left atrial abnormality (LAA)



Right atrial abnormality (RAA)



Atrial Abnormalities

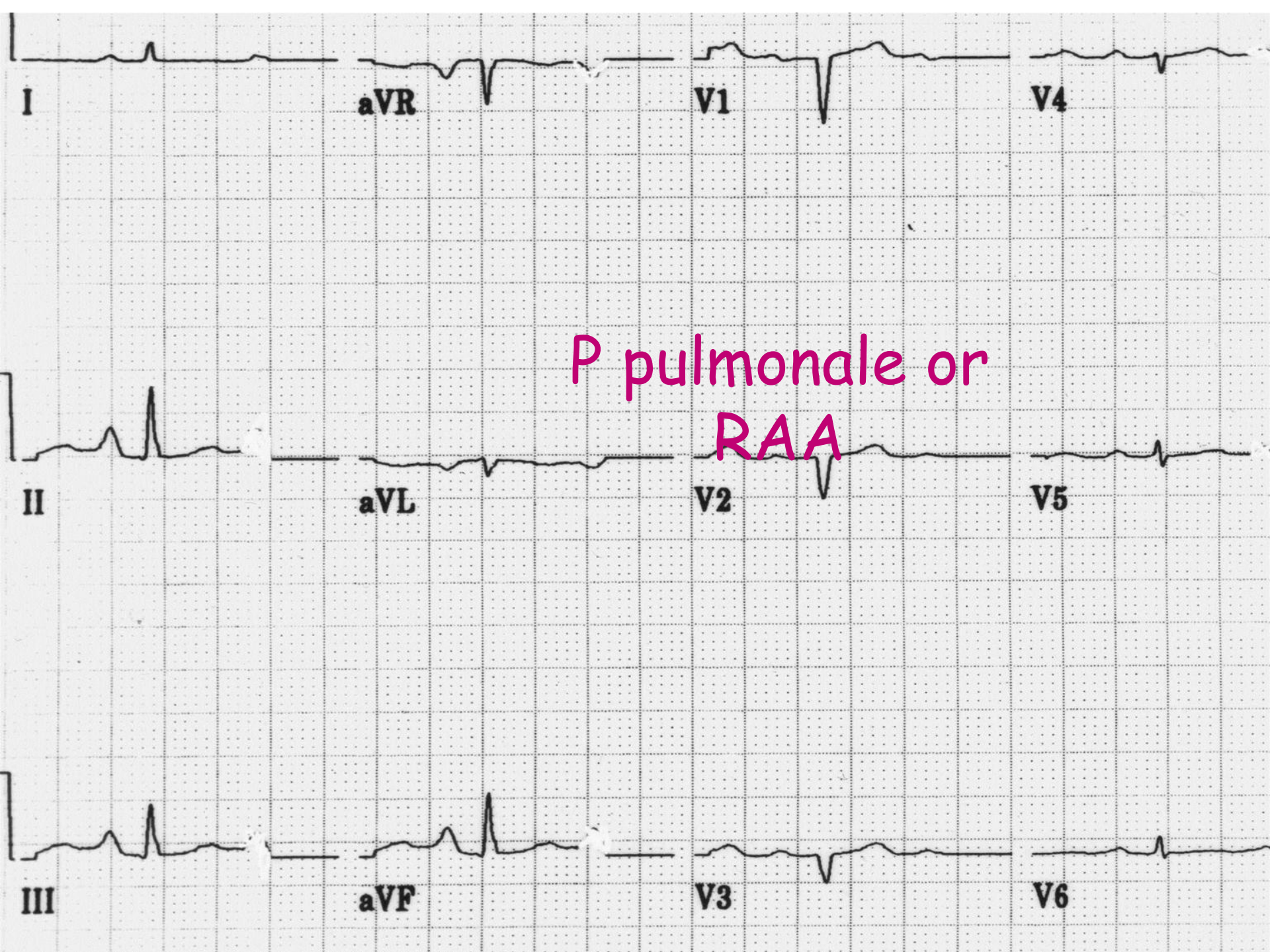
♥ Right (P-pulmonale)

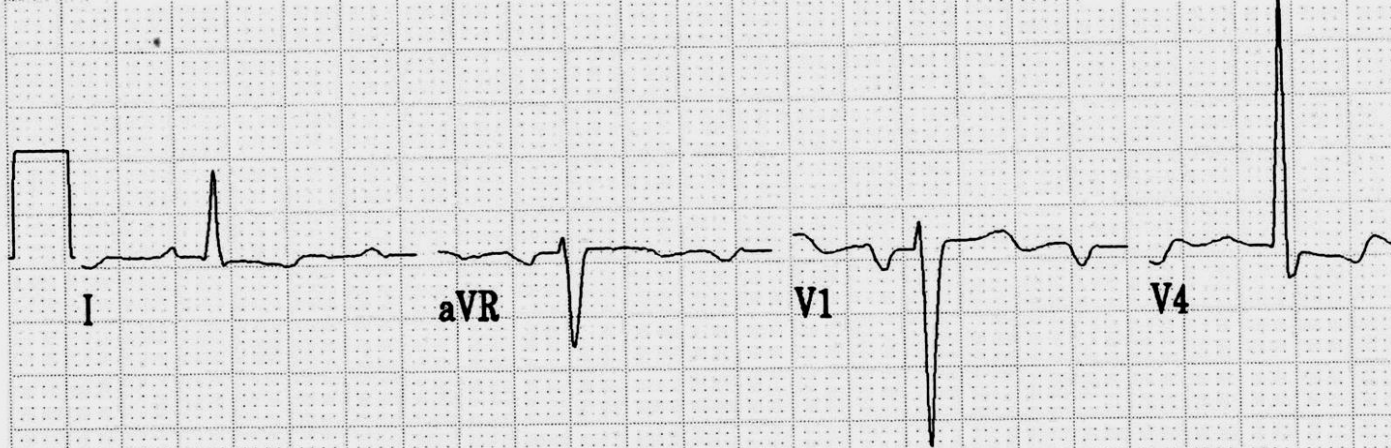
- ♥ Right atrium right heart border, first hump
- ♥ tall, peaked in inferior leads ($>2.5\text{mm}$)

♥ Left (P-mitrale)

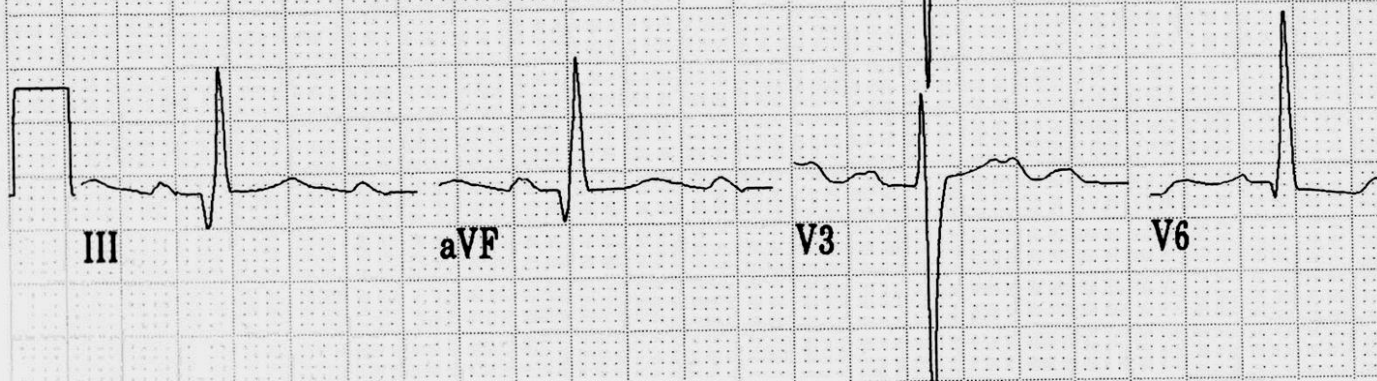
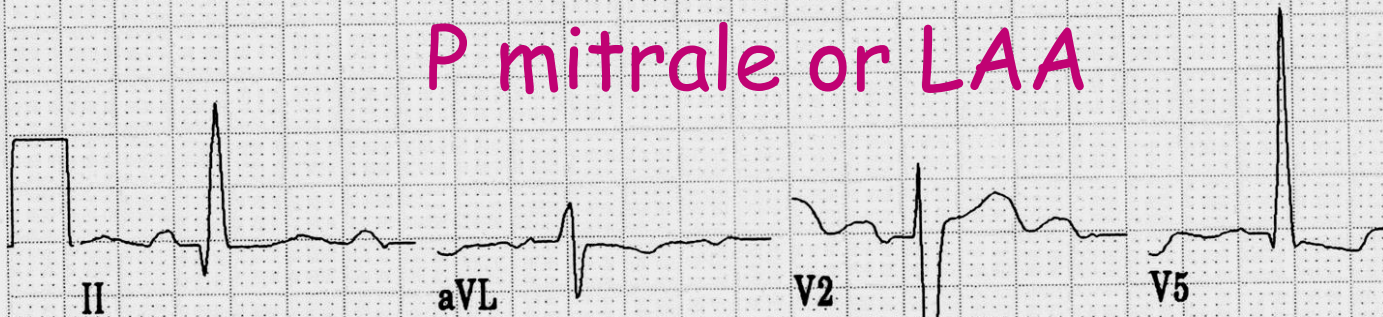
- ♥ Left atrium posterior, second hump
- ♥ broad P wave ($>120\text{msec}$) with negative component in V1-2 ($> 1\text{mm} \times 1\text{mm}$)

Normal = 2.5×2.5 boxes ($100\text{msec} \times .25\text{Mv}$)

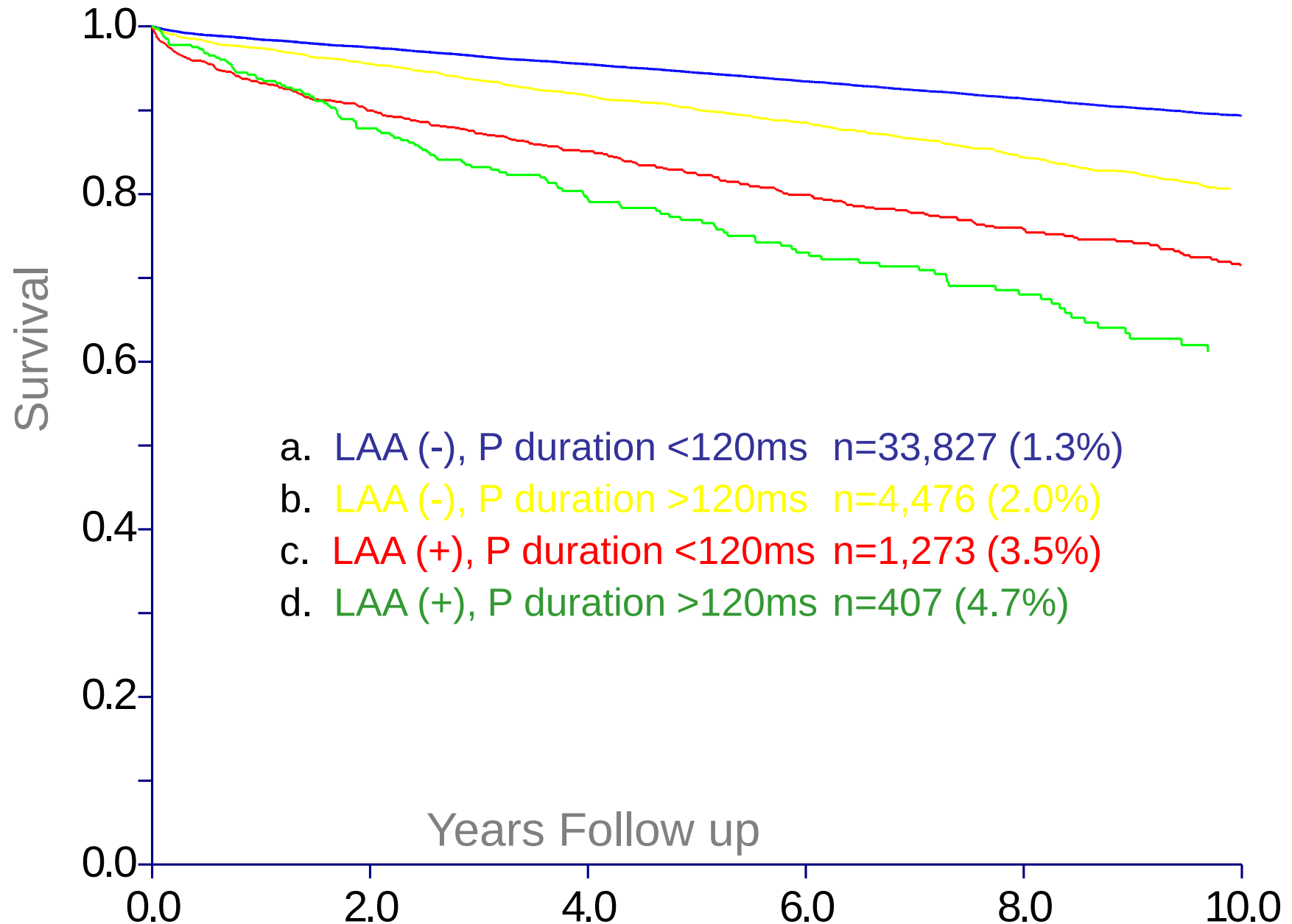




P mitrale or LAA



Computerized LAA with/without P wave prolongation



R > S V1

♥ RVH

♥ RBBB

♥ Inferior Posterior MI

♥ WPW

♥ Normal Variant