Demystifying the ECG in theory and practice

Hypertrophy

Dr Frank Owusu-Sekyere

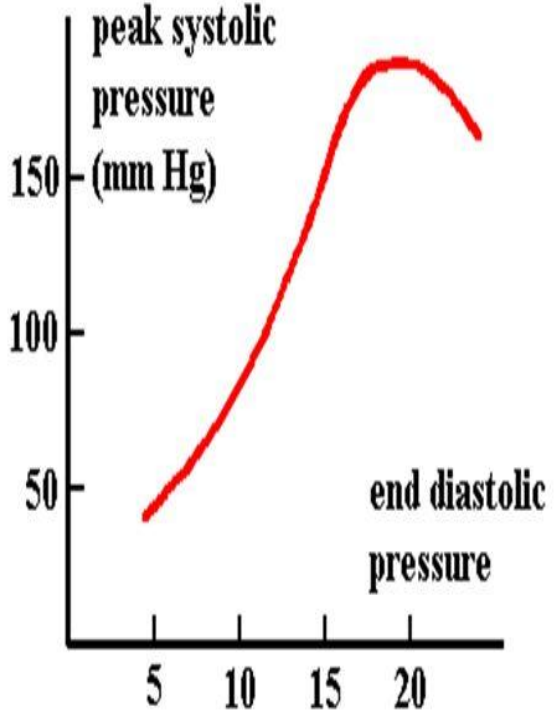
PSG AGSM Pre-conference

6th February 2020

Why hypertrophy?

- Congenital – hypertrophic cardiomyopathies
- acquired- Remodeling of the heart in chronic HF

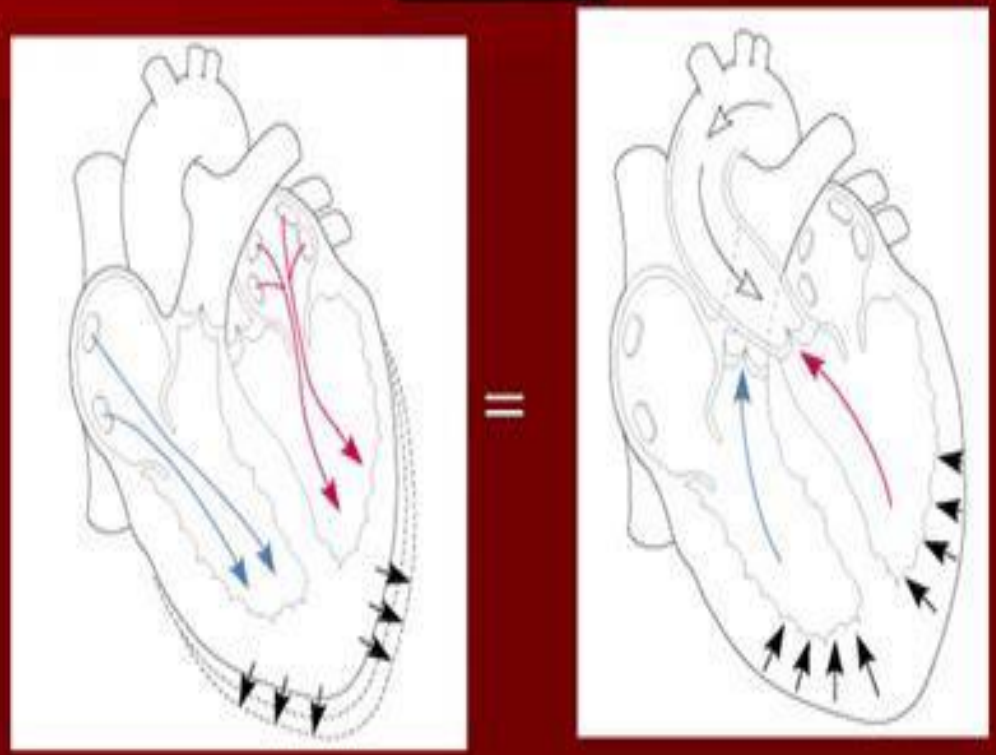
STROKE VOLUME



- **Frank Starling's Law**
  - The greater the volume of blood in the heart during diastole, the more forceful the cardiac contraction, the more blood the ventricle will pump (to a point)

Marian Williams RN

Frank Starling Law of the Heart



Increased blood volume = increased stretch of myocardium

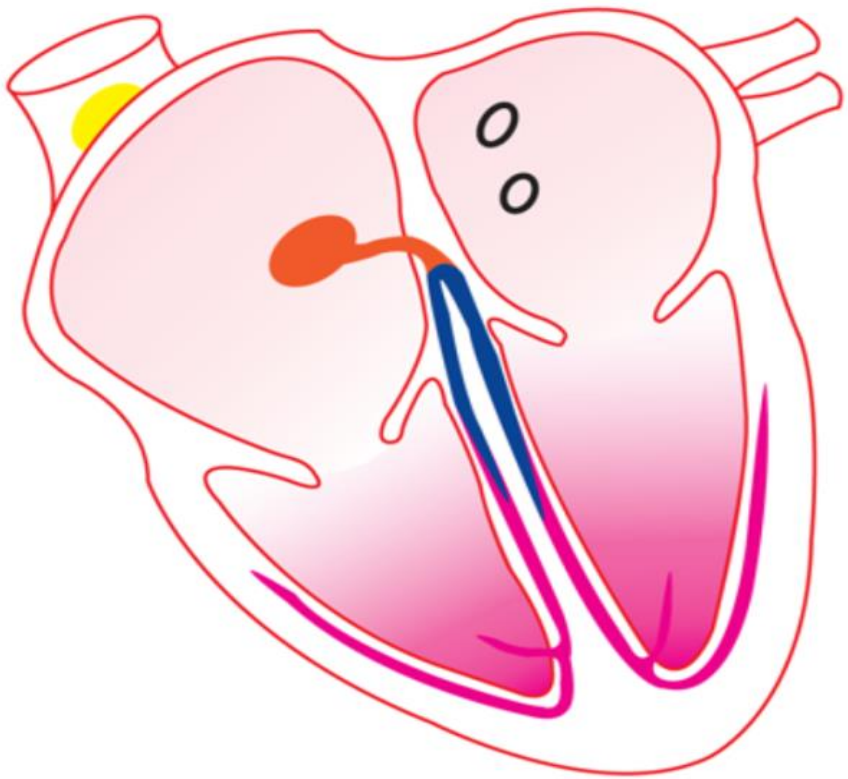
Increased force to pump blood out.

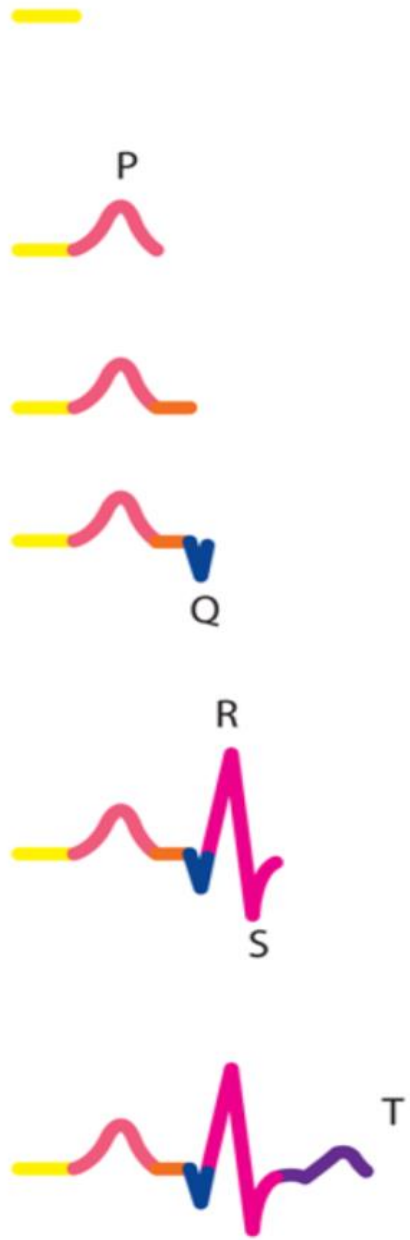
- Increasing SV ----- INCREASED WALL TENSION-----increased oxygen consumption
- Laplace law
- Wall stress = pressure x $\frac{\text{radius}}{2 \times \text{wall thickness}}$

- the bigger the LV (Radius)or pressure, the greater the wall stress

- In HF, Hypertrophy develops to balance the increased pressure and keeps the wall stress unchanged, same as reducing the diameter of the heart.

Cardiac cycle diagram





Sino-atrial node discharge: isoelectric

P wave: atrial activation

AV node/His bundle transmission: isoelectric

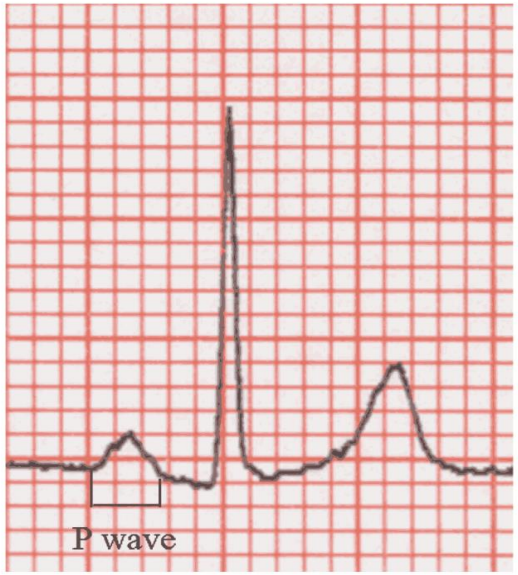
Q wave: septal activation

R/S wave: ventricular activation

T wave: Ventricular repolarization

P-WAVE

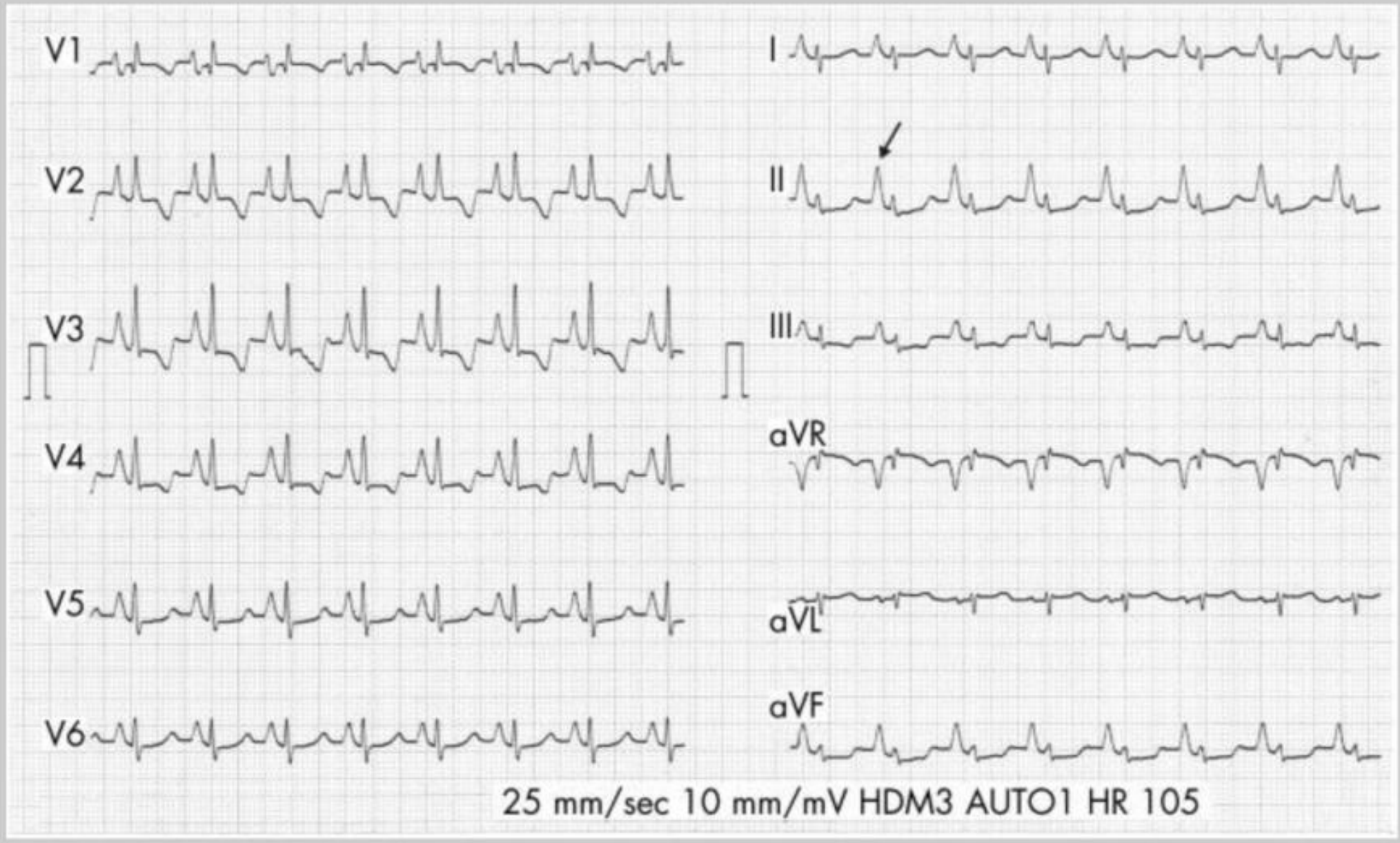
P wave:

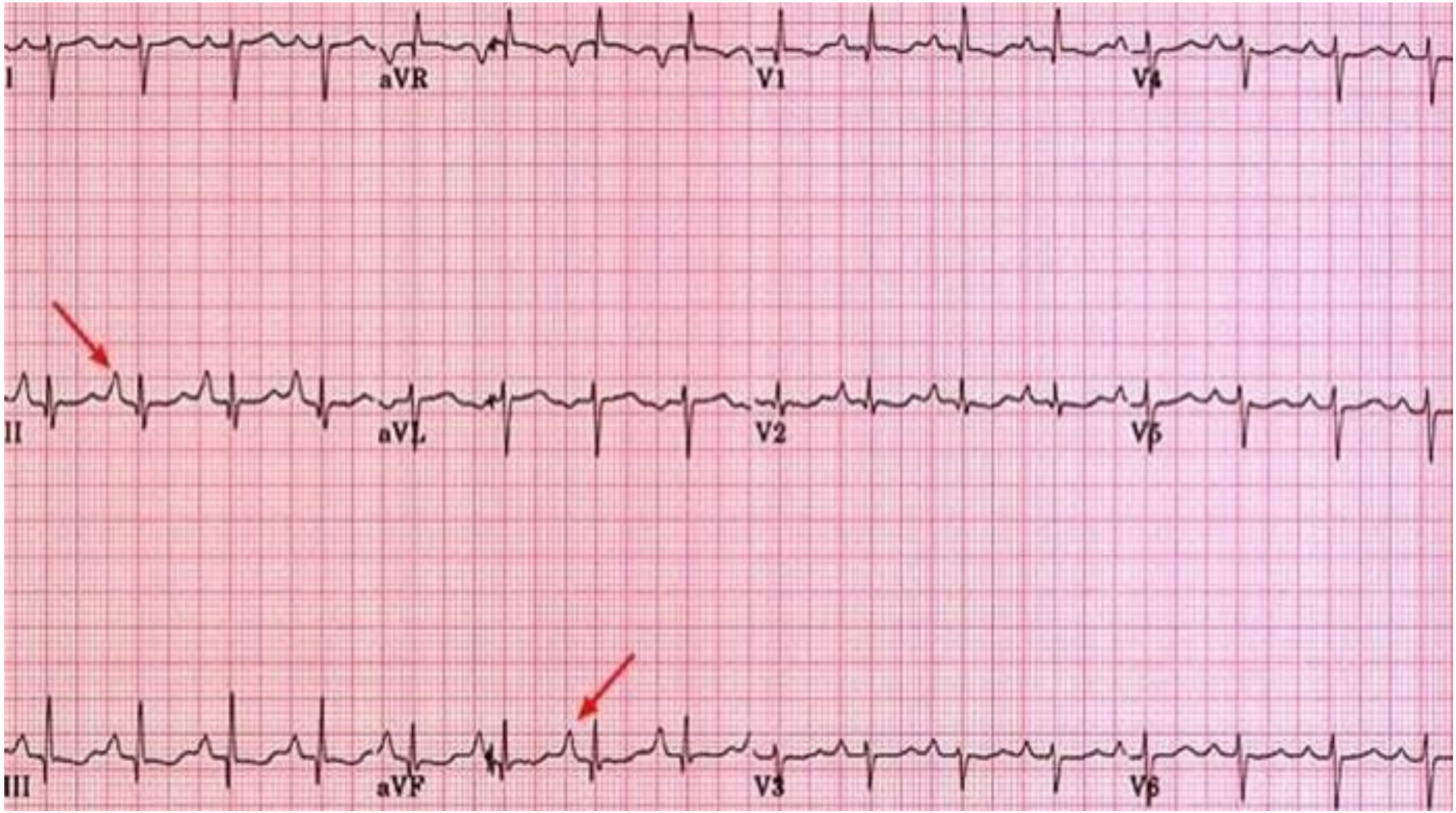


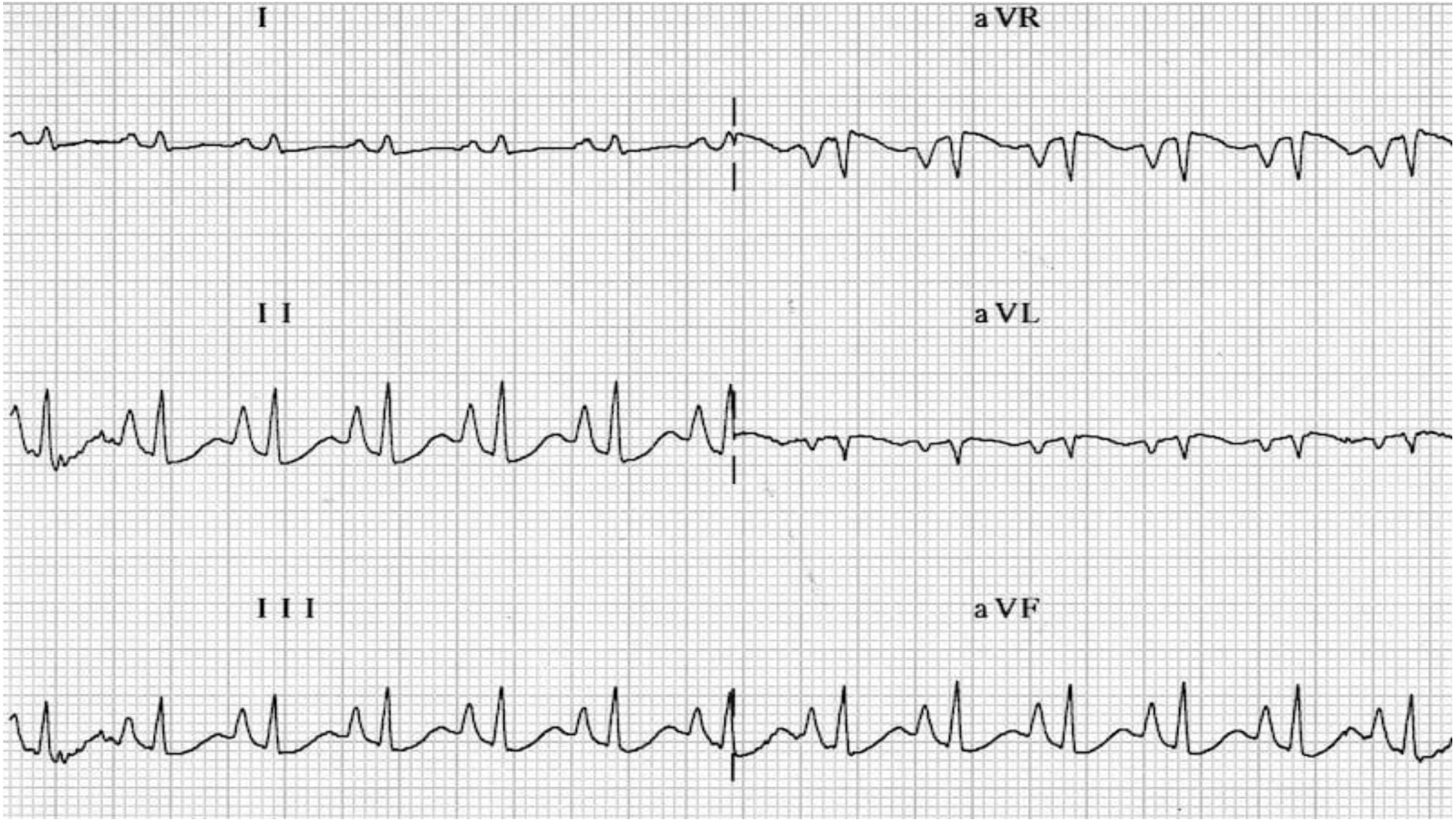
- beginning to end of P wave
- time for atrial depolarization

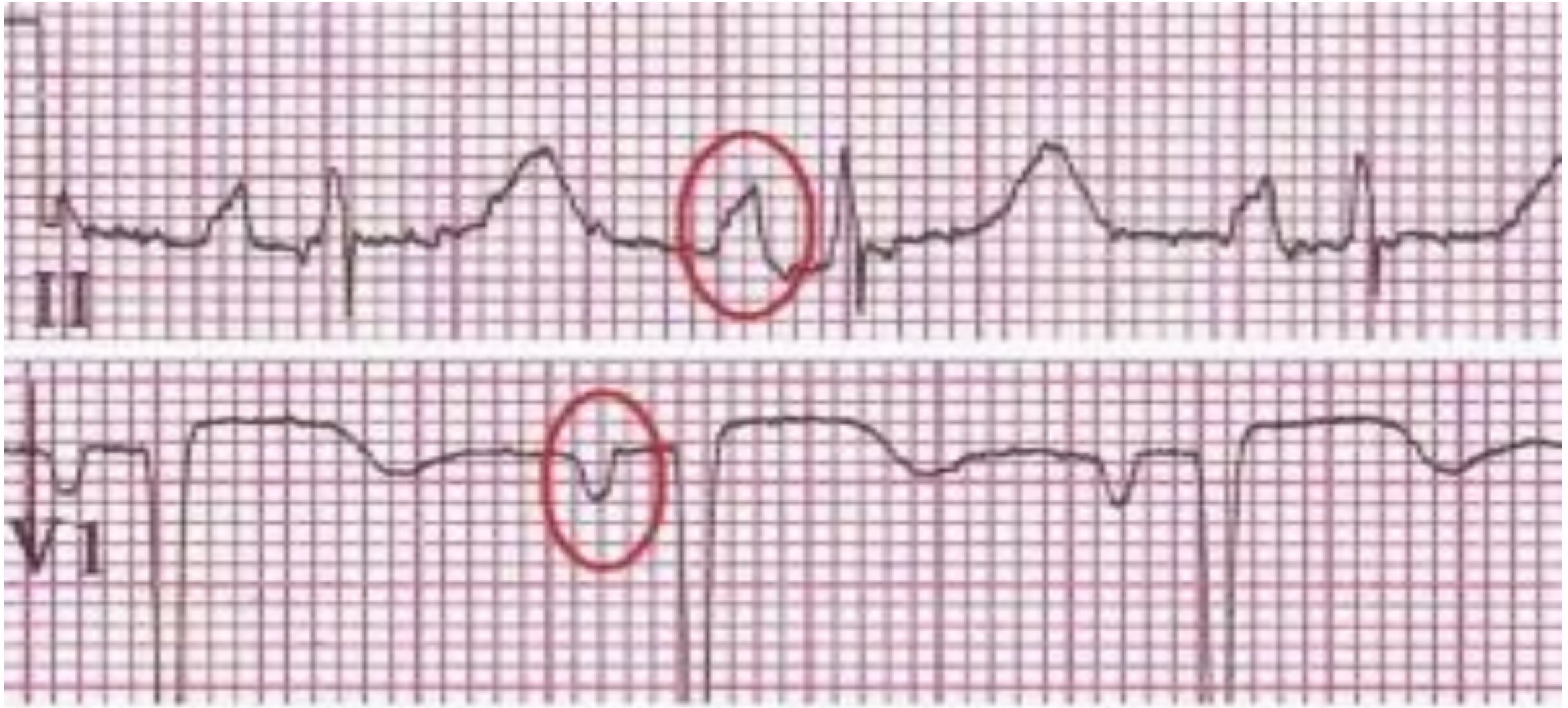
- Gives atrial dimension
- Height- RIGHT (>3mm)
- Width- LEFT (>2.5 small squares in children or 2 small squares in infants)

Figure 3-14 Criteria for atrial hypertrophy. BAH, biatrial hypertrophy; LAH, left atrial hypertrophy; RAH, right atrial hypertrophy. *(From Park MK, Guntheroth WG: How to Read Pediatric ECGs, 4th ed. Philadelphia, Mosby, 2006.)*


V1
V2
V3
V4
V5
V6
I
II
III
aVR
aVL
aVF
25 mm/sec 10 mm/mV HDM3 AUTO1 HR 105


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

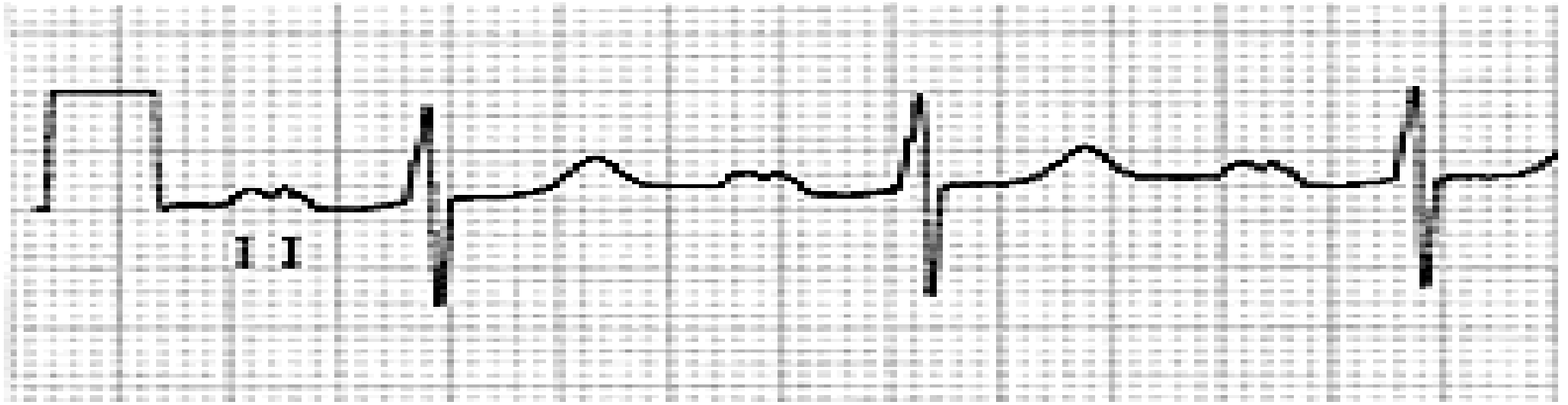

I
aVR
II
aVL
III
aVF



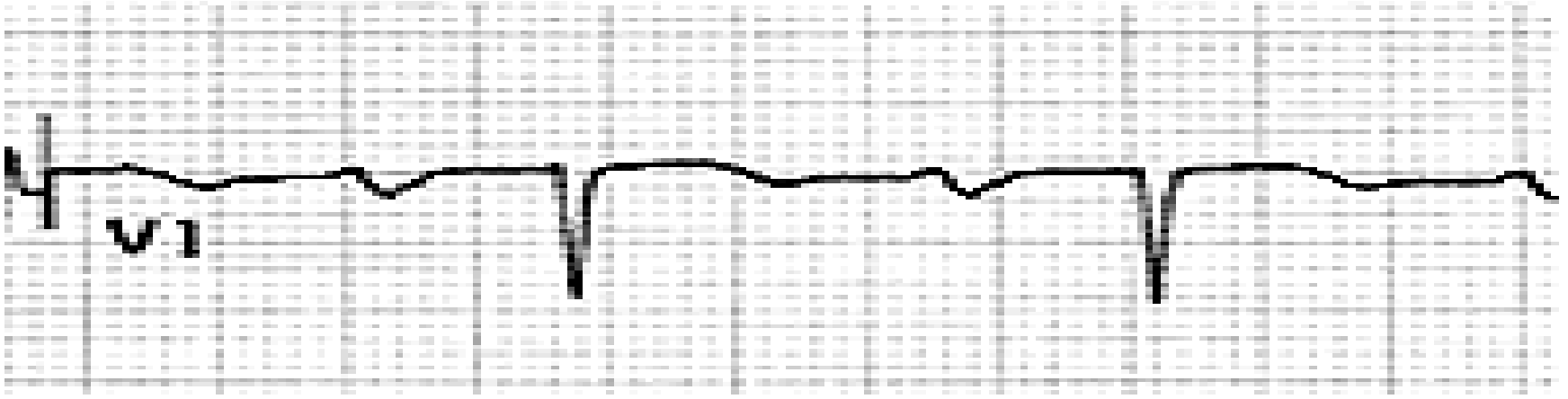
[redacted] Enlargement / [redacted]

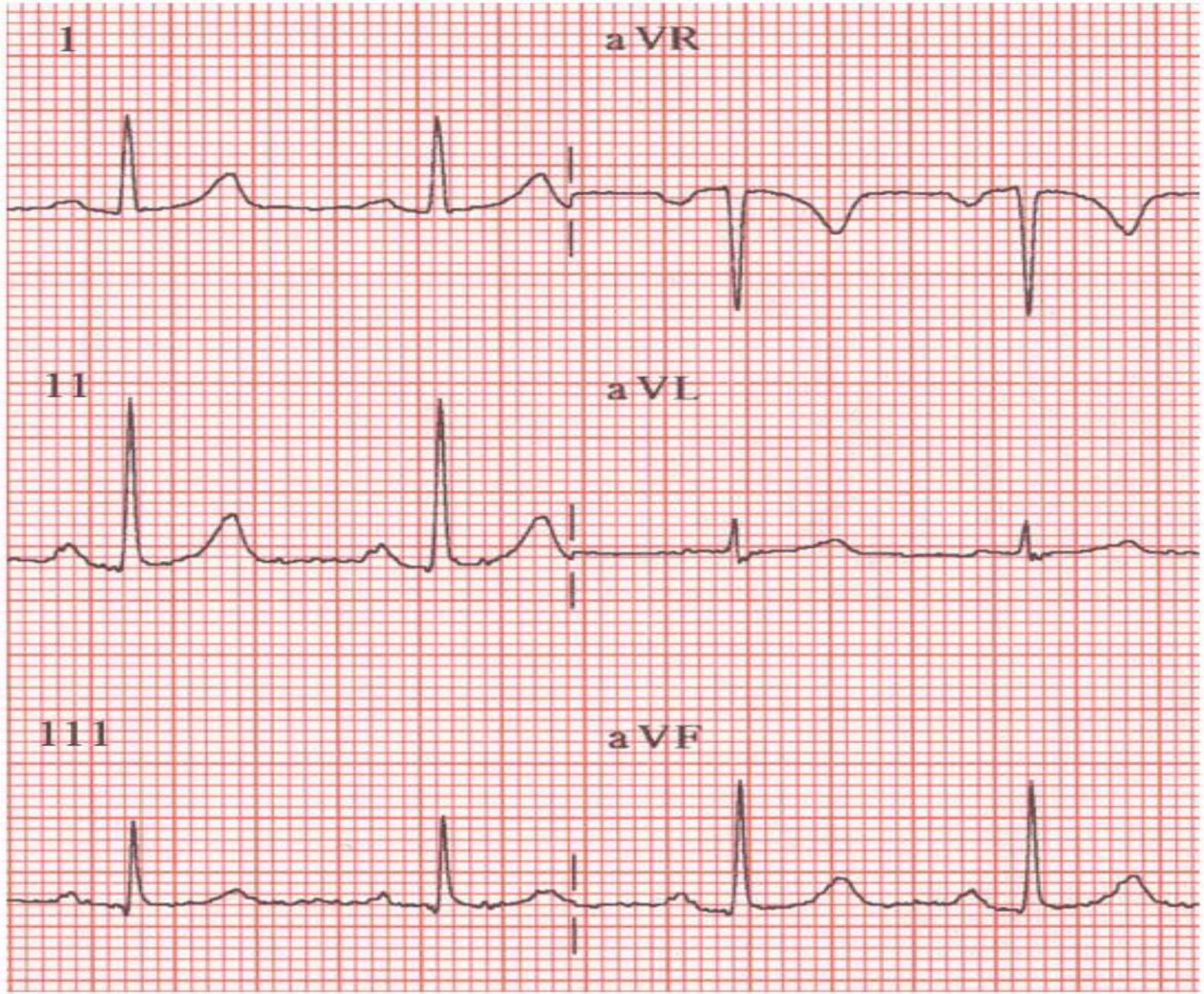
EMS12lead.com

Lead II



Lead V_1

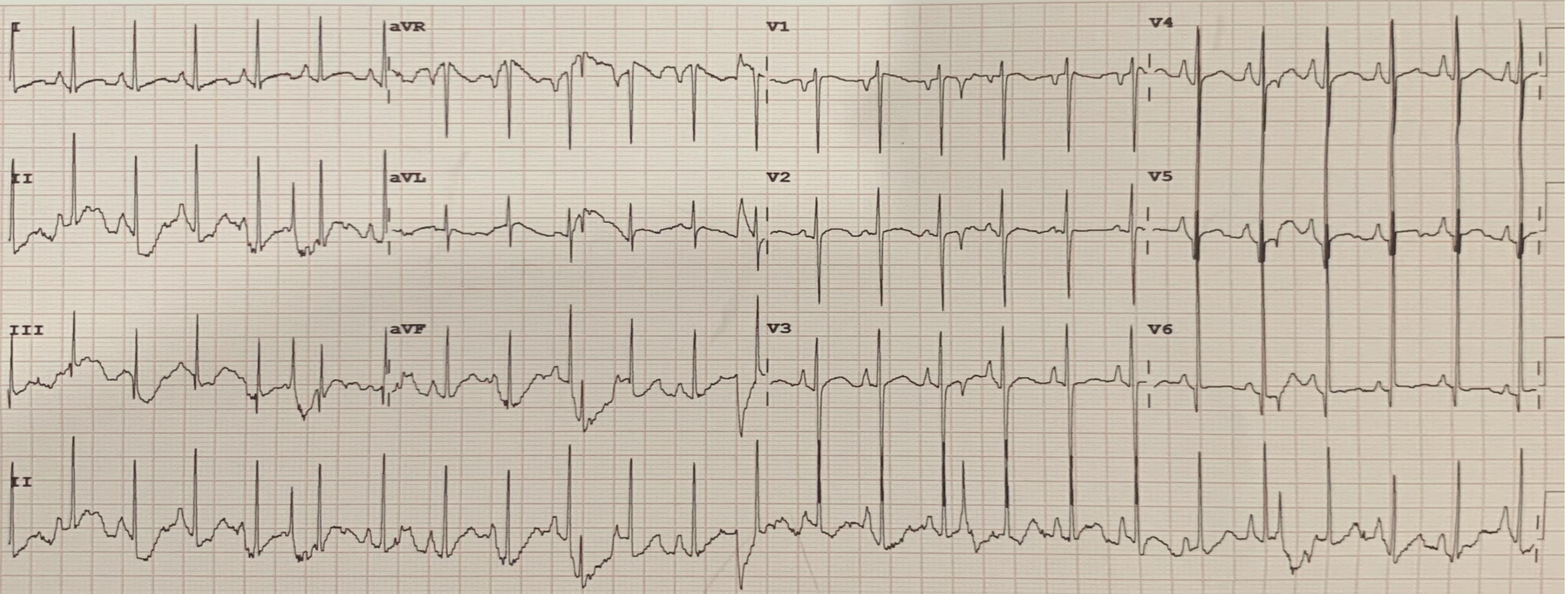



I
aVR
II
aVL
III
aVF

- ABNORMAL ECG -

12 Lead; Standard Placement

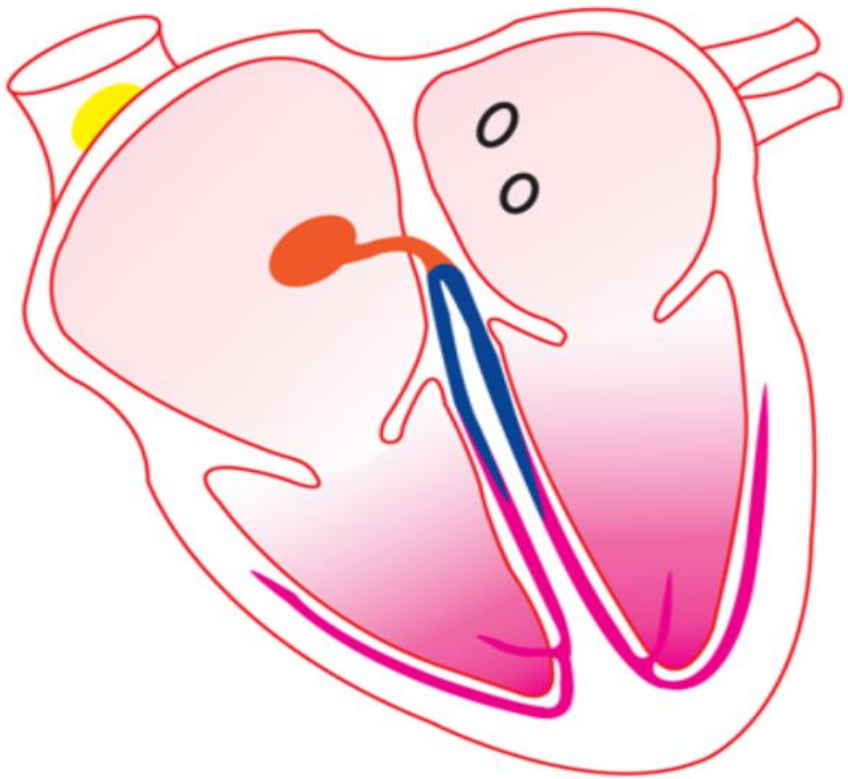
Unconfirmed Diagnosis

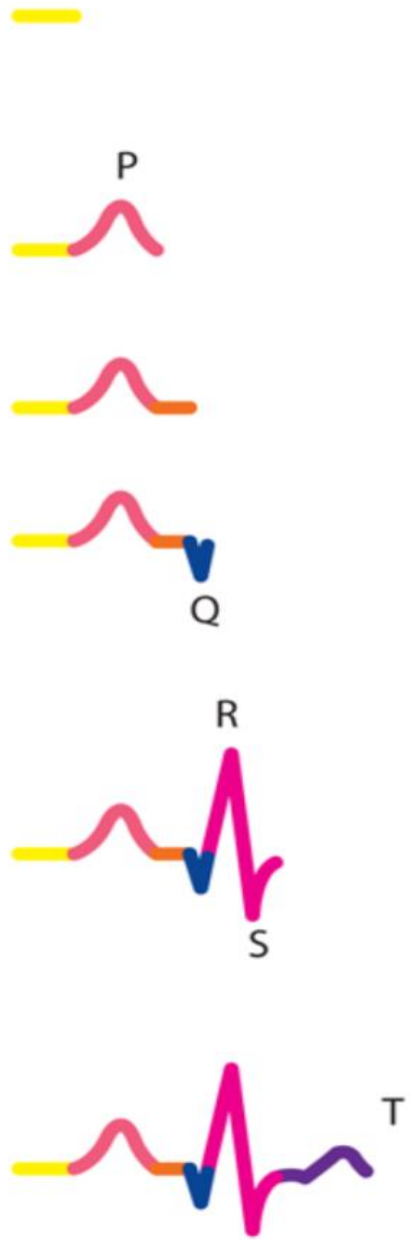


Device: Speed: 25 mm/sec Limb: 10 mm/mV Chest: 10.0 mm/mV

F 60~ 0.15-100 Hz PH100B CL?

Cardiac cycle diagram





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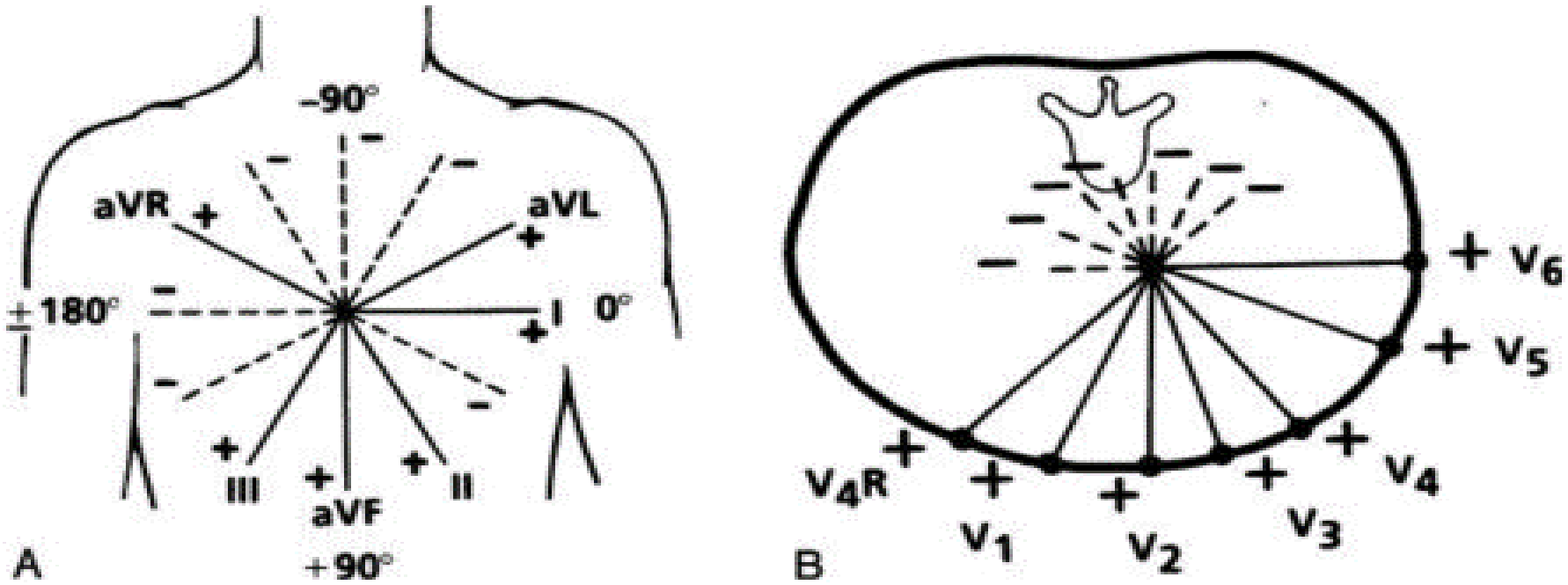
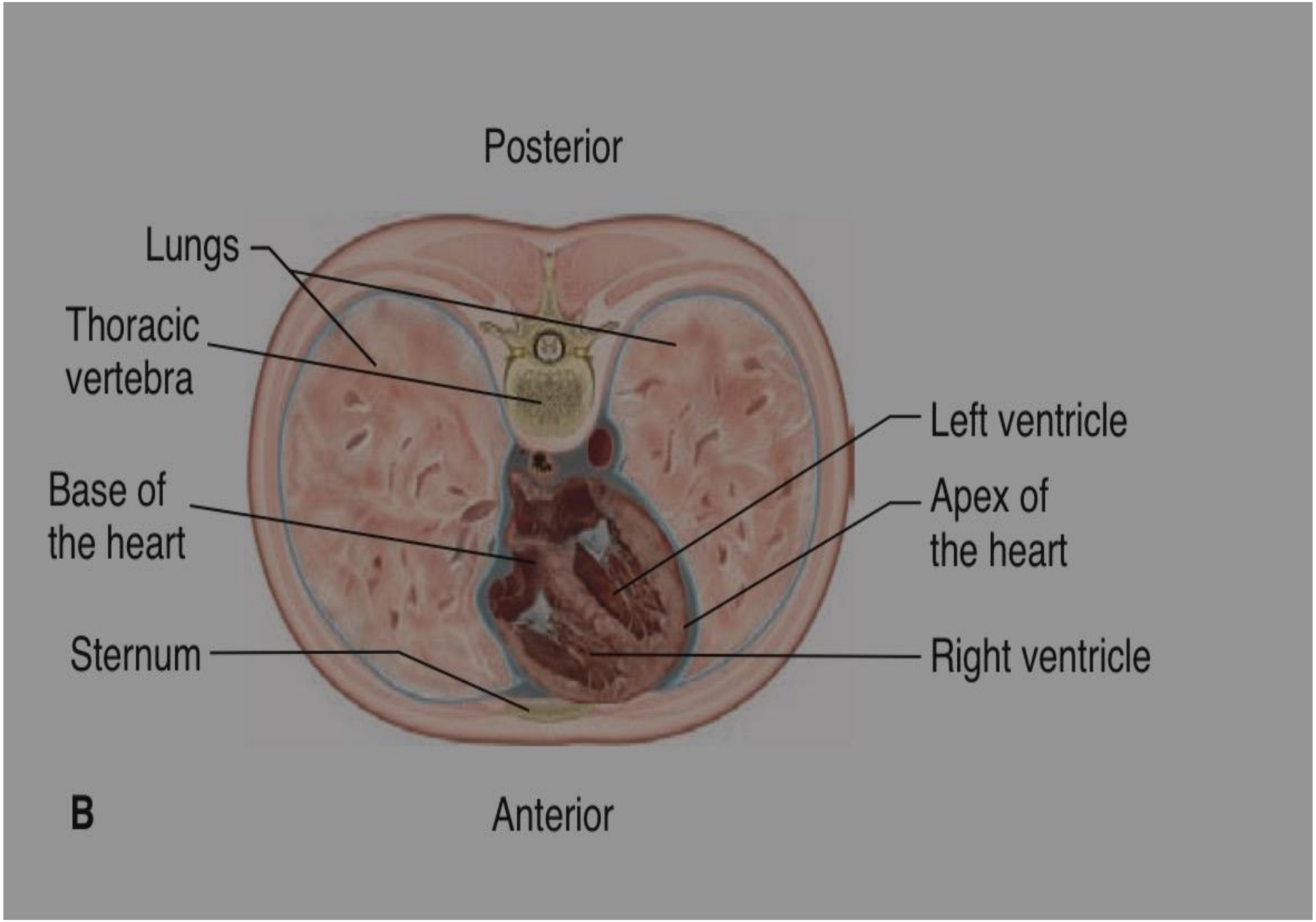


Figure 3-1 Hexaxial reference system (**A**) shows the frontal projection of a vector loop, and horizontal reference system (**B**) shows the horizontal projection. The combination of **A** and **B** constitutes the 12-lead (or 13-lead) electrocardiogram. *(From Park MK, Guntheroth WG: How to Read Pediatric ECGs, 4th ed. Philadelphia, Mosby, 2006.)*


Posterior
Lungs
Thoracic vertebra
Base of the heart
Sternum
Left ventricle
Apex of the heart
Right ventricle
B
Anterior

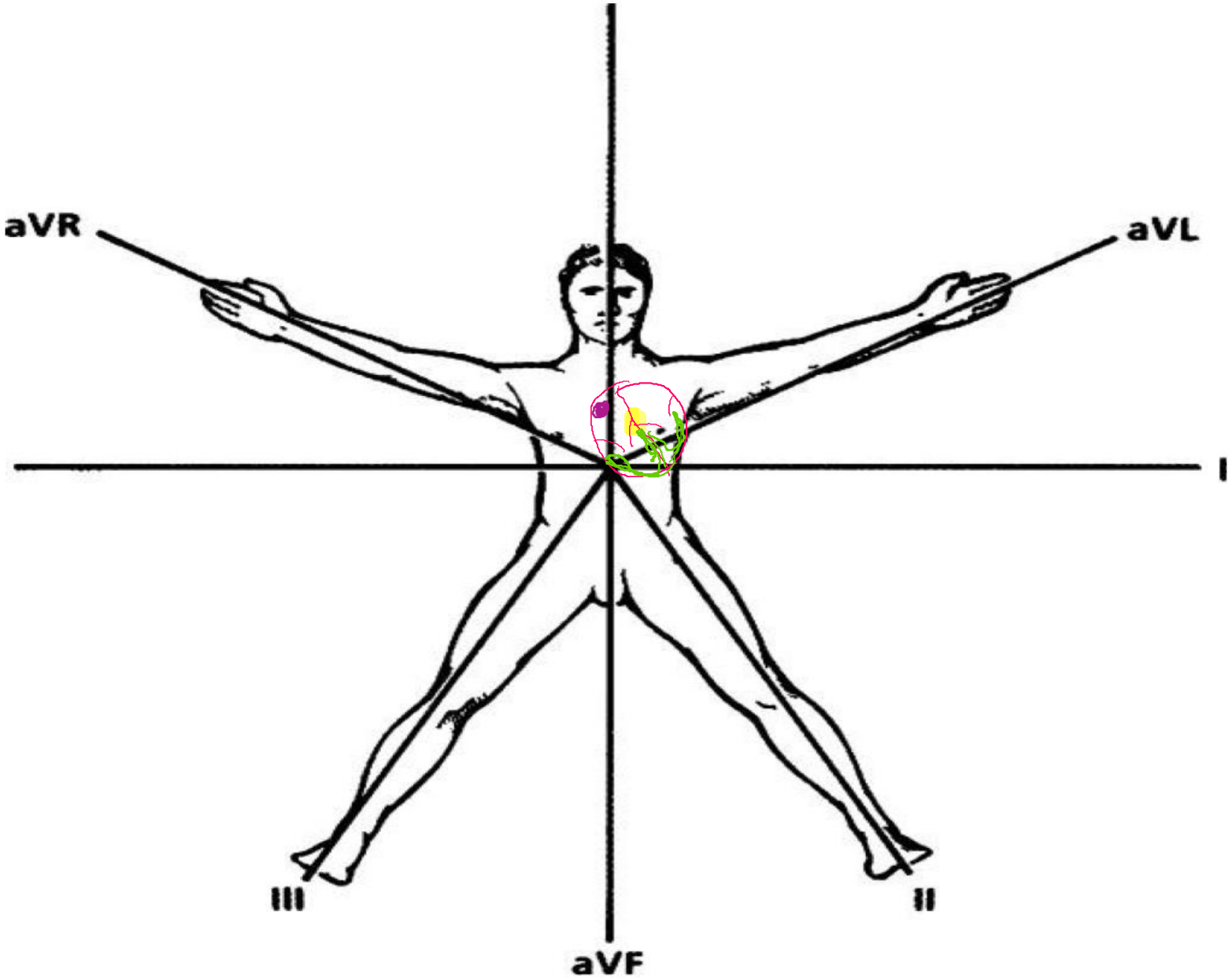


Figure 3-2 An easy way to memorize the hexaxial reference system. *(From Park MK, Guntheroth WG: How to Read Pediatric ECGs, 4th ed. Philadelphia, Mosby, 2006.)*

VENTRICLES

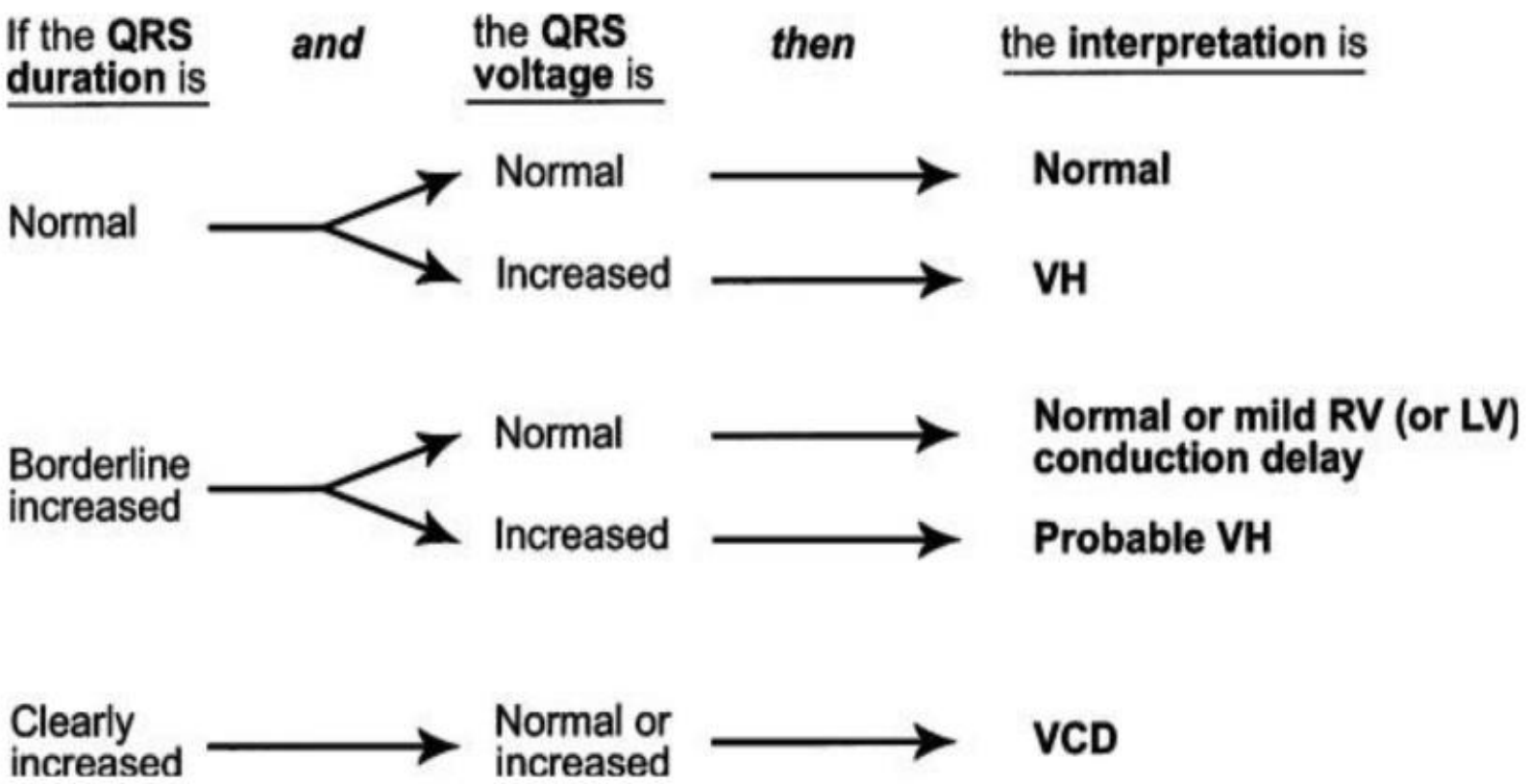


Figure 3-22 Algorithm for differentiating between ventricular hypertrophy (VH) and ventricular conduction disturbances (VCDs). LV, left ventricle; RV, right ventricle.

GENERAL PRINCIPLES OF VENTRICULAR HYPERTROPHY

- **CHANGES IN QRS AXIS**

-directed toward the hypertrophied ventricle

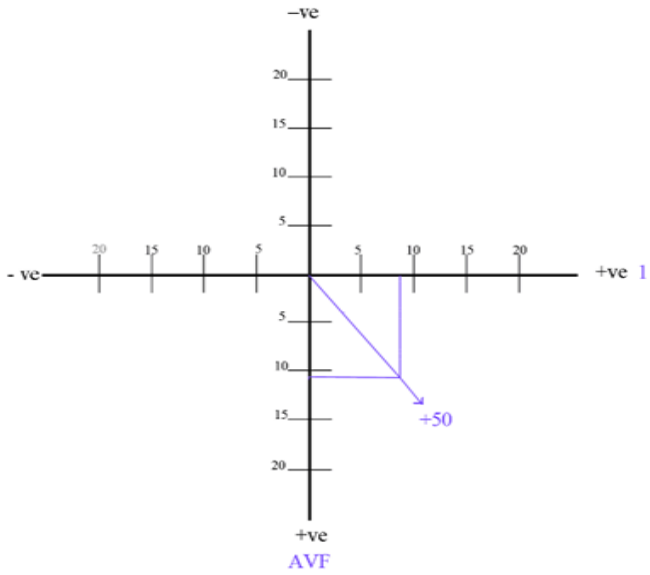
- RAD seen in RVH

-LAD- LVH with volume overload but no pressure overload

-Marked LAD indicates VCD

Plot on appropriate limb of lead axis

- Draw perpendicular line from each point until lines intersect
- QRS axis = line from centre to intersection



ECG 1: QRS axis calculates to +50

CHANGES IN QRS VOLTAGE

- **CHANGES IN QRS VOLTAGE**

-RVH ----Voltages increases in leads that look at right or a negative in leads that look at LV

LVH- Voltages increase in leads that look at LV and negative for those that look at the right

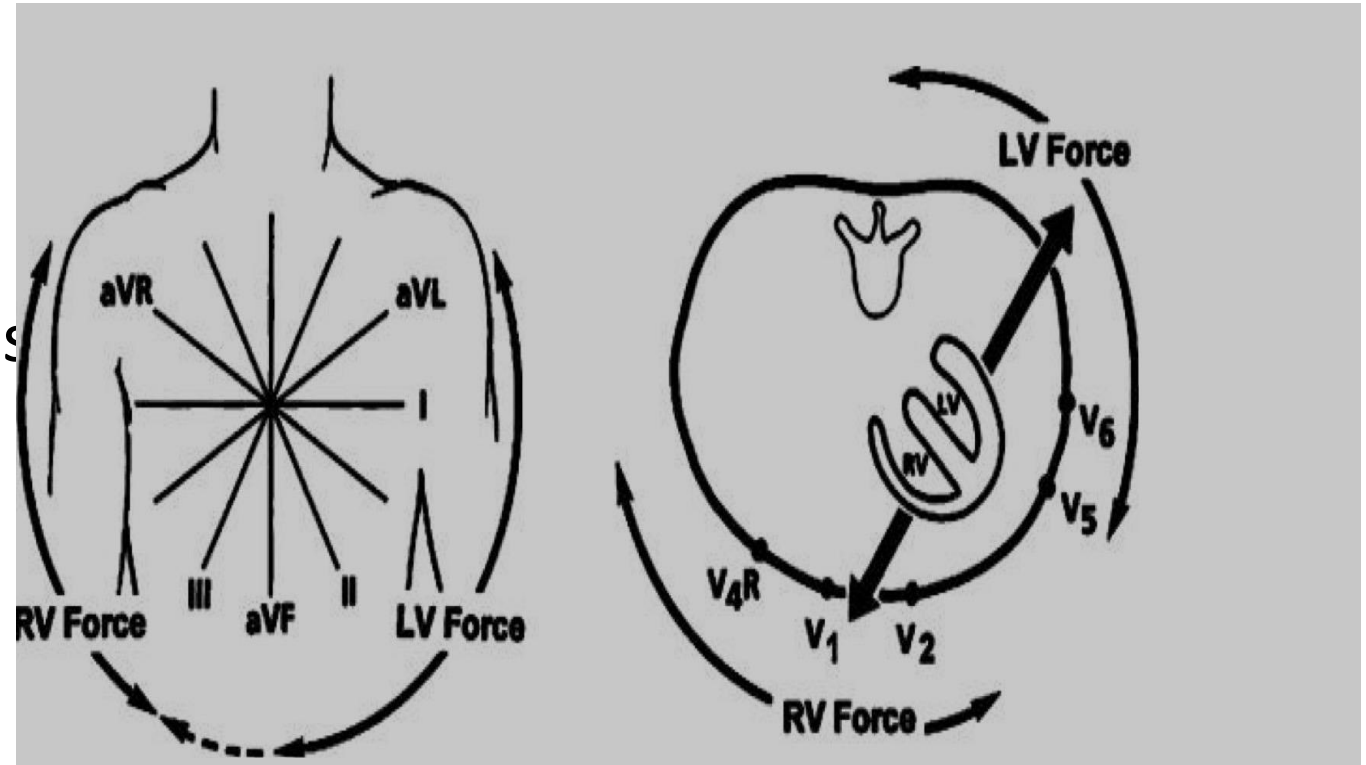


Figure 3-15 Diagrammatic representation of left and right ventricular forces on the frontal projection or hexaxial reference system (**A**) and the horizontal plane (**B**). LV, left ventricular; RV, right ventricular. *(From Park MK, Guntheroth WG: How to Read Pediatric ECGs, 4th ed. Philadelphia, Mosby, 2006.)*

CHANGES IN R/S RATIO

- R/S ratio represents the relative electromotive force of opposing ventricles
- In VH, a change may be seen in the R/S ratio without an increase in the absolute voltage
- Increase in right precordial leads-RVH
- Decrease in RT precordial leads –LVH
- Increase in LT leads –LVH
- Decrease in LT leads -RVH

Table 3-5 -- R/S Ratio: Mean and Upper and Lower Limits of Normal According to Age

Lead		0–1 mo	1–6 mo	6 mo–1 yr	1–3 yr	3–8 yr	8–12 yr	12–16 yr	Adult
V1	LLN	0.5	0.3	0.3	0.5	0.1	0.15	0.1	0.0
	Mean	1.5	1.5	1.2	0.8	0.65	0.5	0.3	0.3
	ULN	19	S = 0	6	2	2	1	1	1
V2	LLN	0.3	0.3	0.3	0.3	0.05	0.1	0.1	0.1
	Mean	1	1.2	1	0.8	0.5	0.5	0.5	0.2
	ULN	3	4	4	1.5	1.5	1.2	1.2	2.5
V6	LLN	0.1	1.5	2	3	2.5	4	2.5	2.5
	Mean	2	4	6	20	20	20	10	9
	ULN	S = 0	S = 0	S = 0	S = 0	S = 0	S = 0	S = 0	S = 0

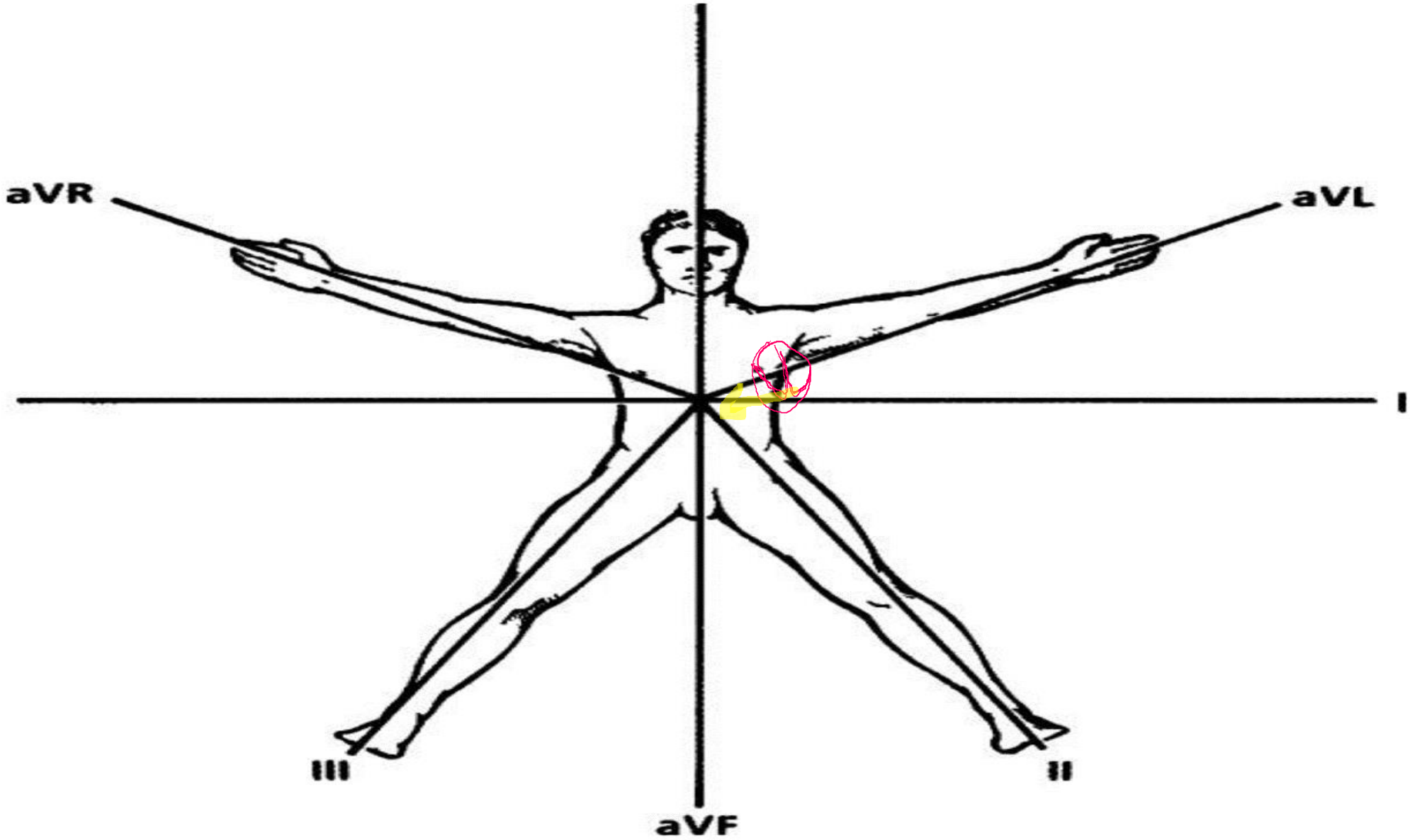
From Guntheroth WB: Pediatric Electrocardiography. Philadelphia, WB Saunders, 1965.

LLN, lower limits of normal; ULN, upper limits of normal.

- Changes in T-axis
- Changes seen in severe ventricular hypertrophy with relative ischemia of the hypertrophied myocardium
- Upright T-wave in V1 RVH
- Q- wave in V1- RVH
- Deep Q-wave (>5mm) as well as Tall T-wave (>15mm) in V5, V6 suggest LVH of volume loading type

Left Ventricular Hypertrophy

- Increased R voltages in frontal left leads (I, II, aVL , aVF)
- Tall R in V5, V6 and/or S wave in V1,V2 ,V4R
- Decreased R/S ratio in Right praecordial leads
- Increased R/S ratio in V5,V6



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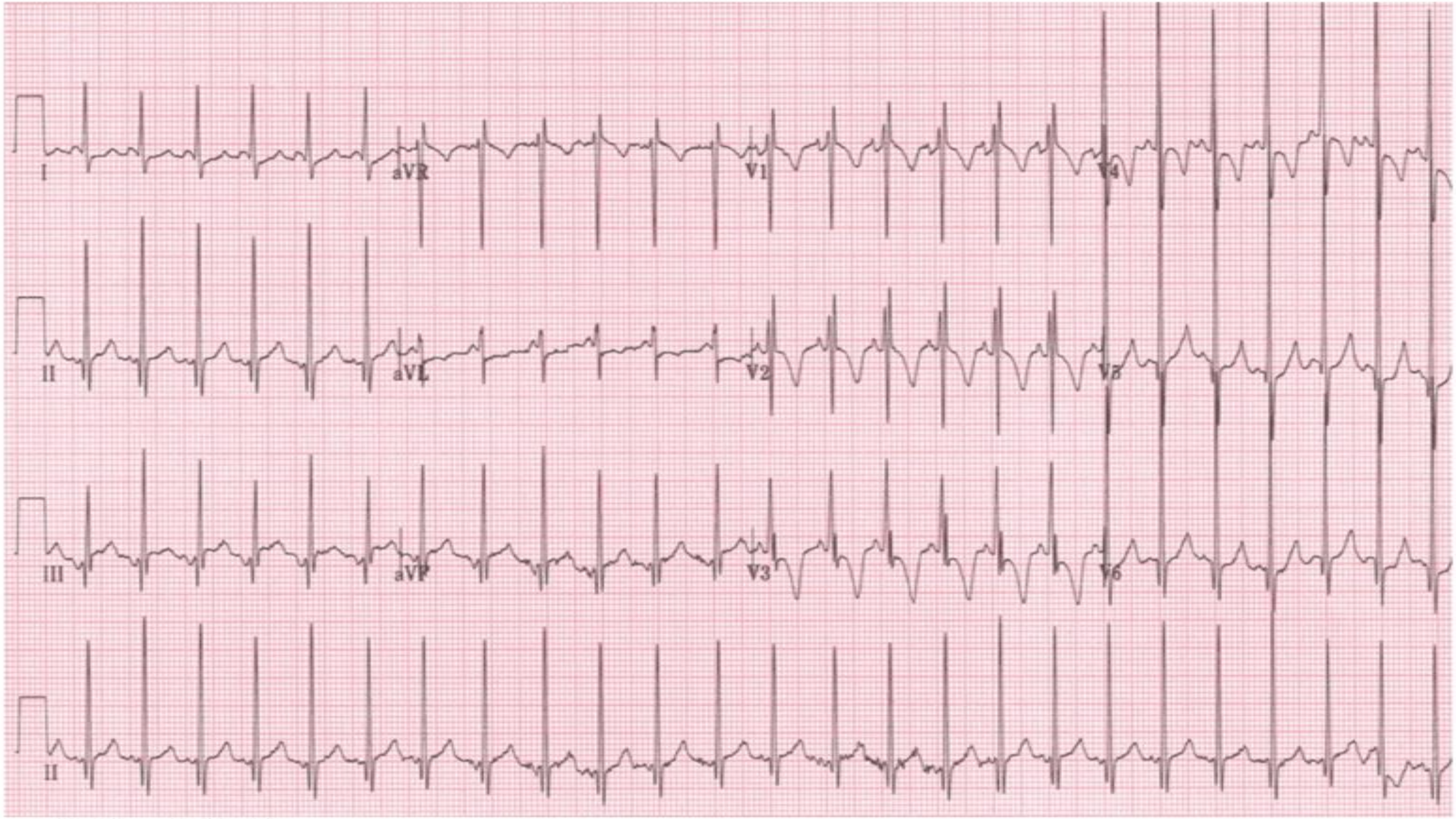
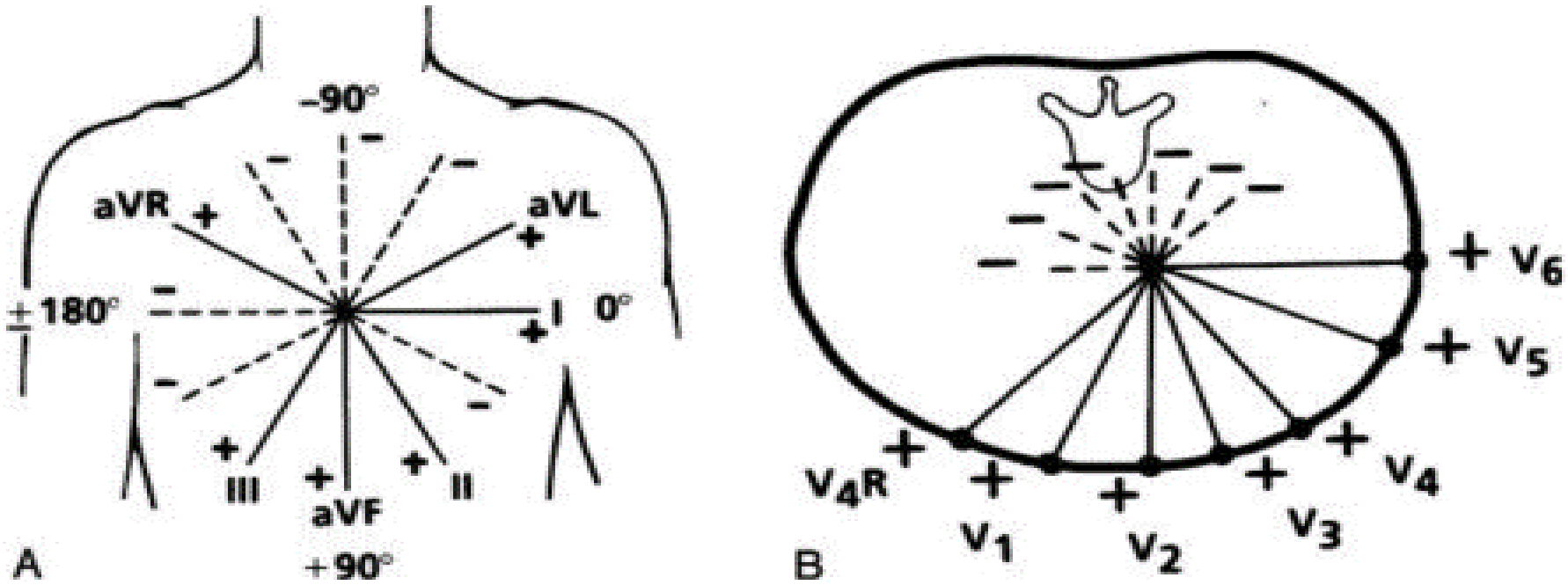
ECG 2: LVH. 5 m old. post-Aortic Valvotomy



q V6 = 5mm; R V6 >30mm

RVH

- Increased R voltage in aVR, III, Deep S in I
- Increased R in V4R, V1, V2 and S in V5, V6
- Increased R/S in Rt chest leads
- Decreased R/S in V5, V6
- T-wave
- RAD



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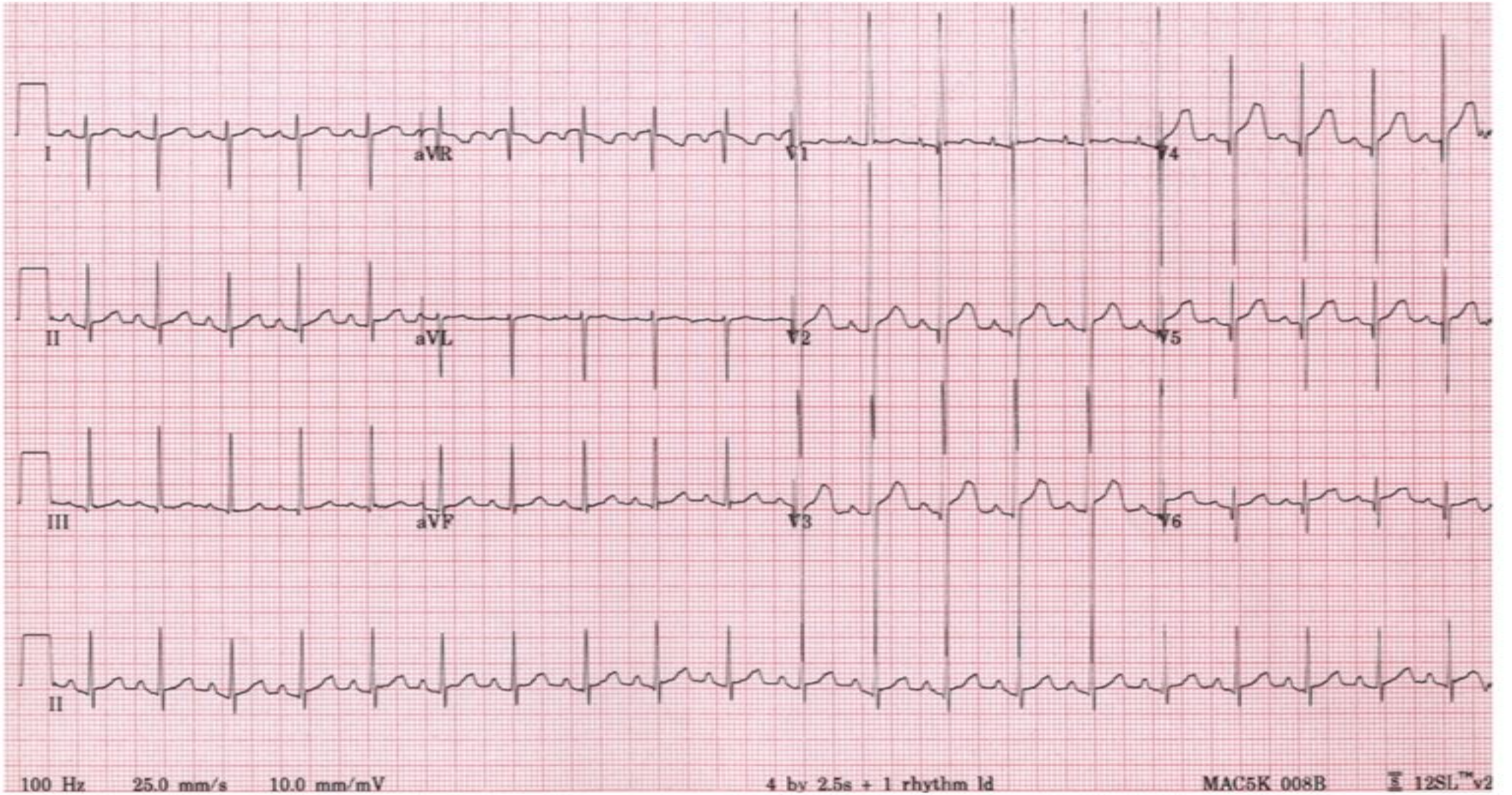

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
100 Hz
25.0 mm/s
10.0 mm/mV
4 by 2.5s + 1 rhythm ld
MAC5K 008B
12SL™v2

Biventricular hypertrophy

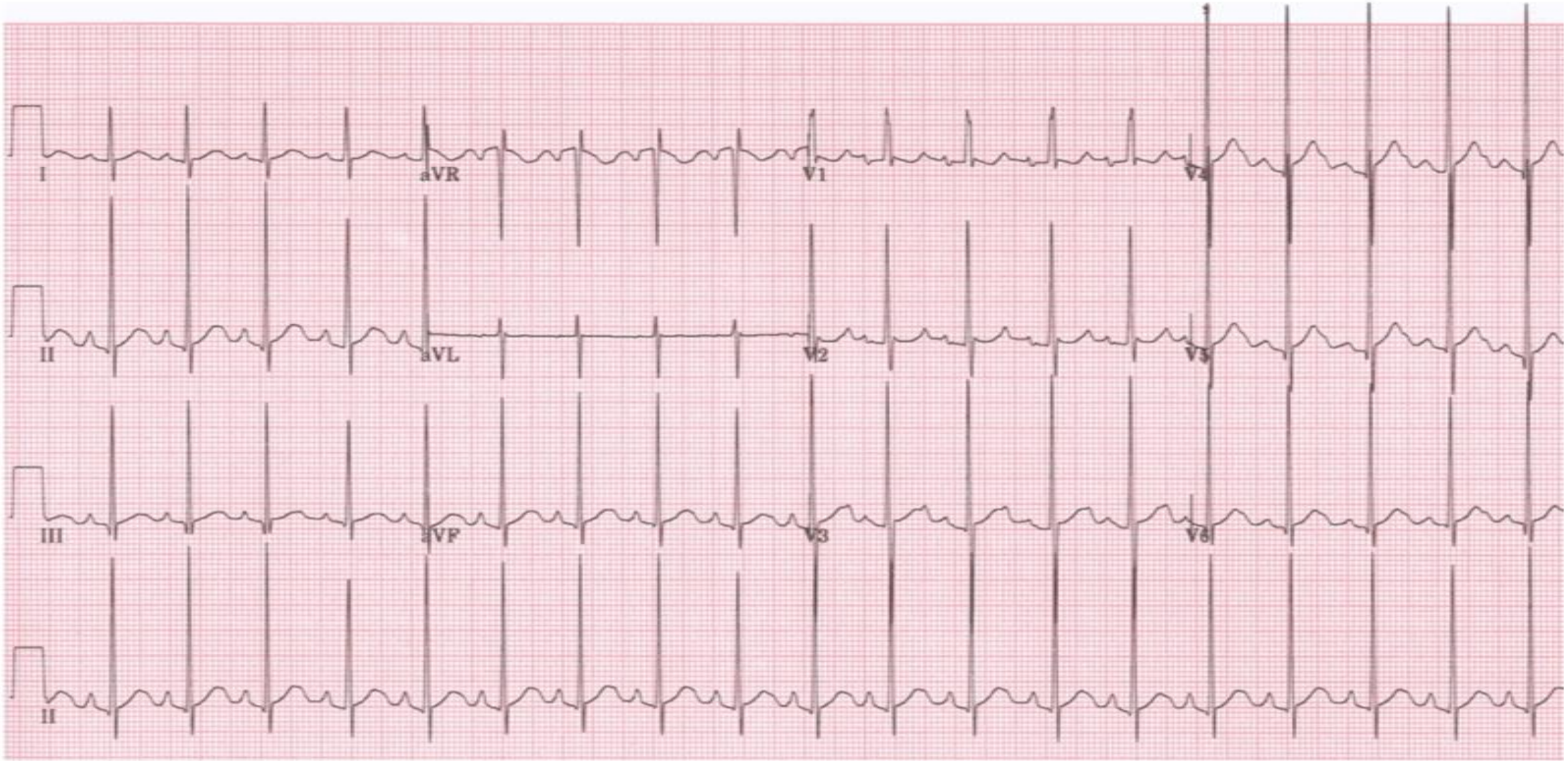
- Positive voltage criteria for RVH and LVH, absence of BBB or Preexcitation

- Katz-Wachtel Phenomenon

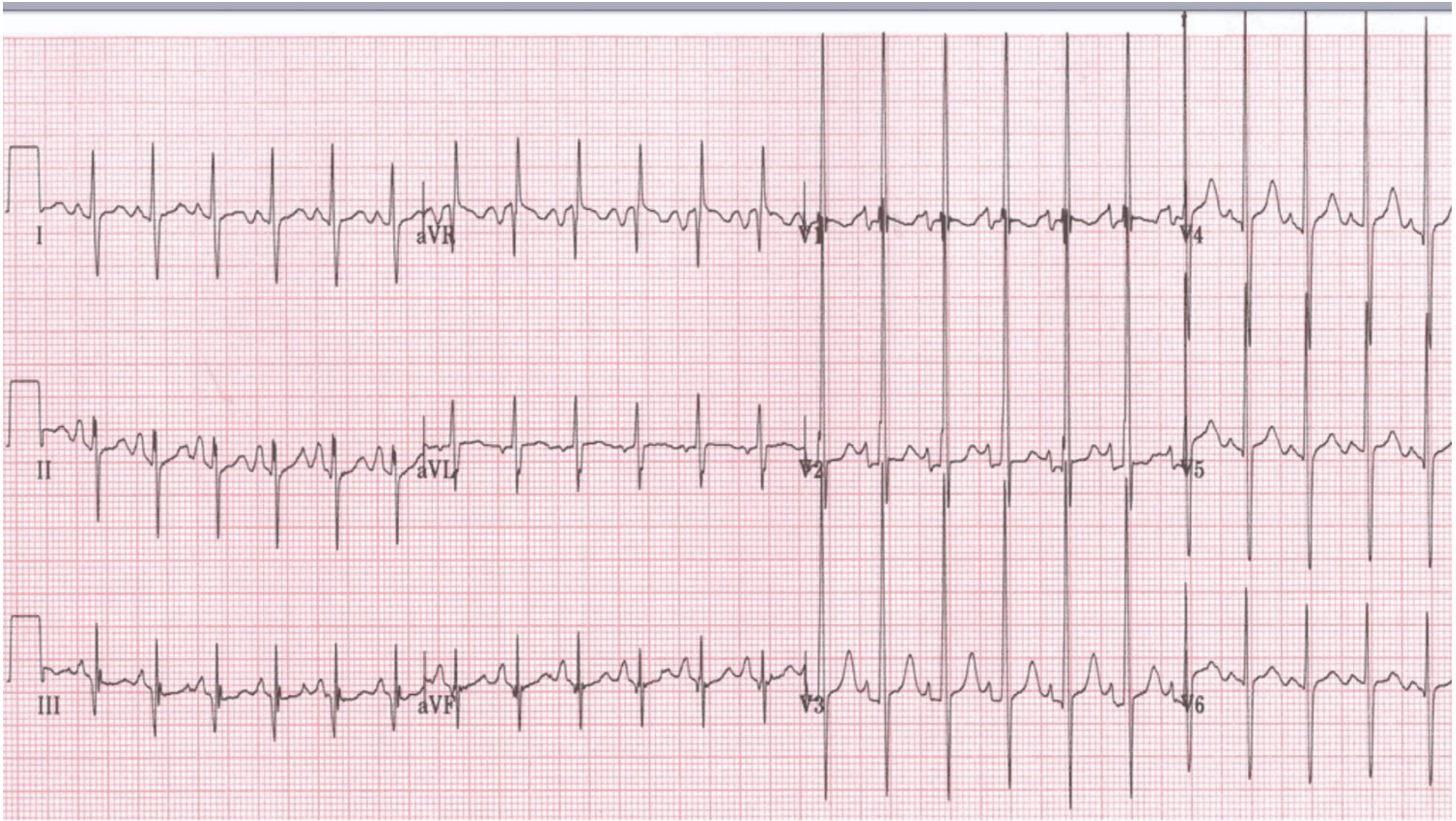
- Large equiphasic QRS in 2 or more limb leads

- And mid-precordial leads (V2-V5)

ECG: Biventricular hypertrophy. 1 yr girl. Severe branch PS and Aortic hypoplasia

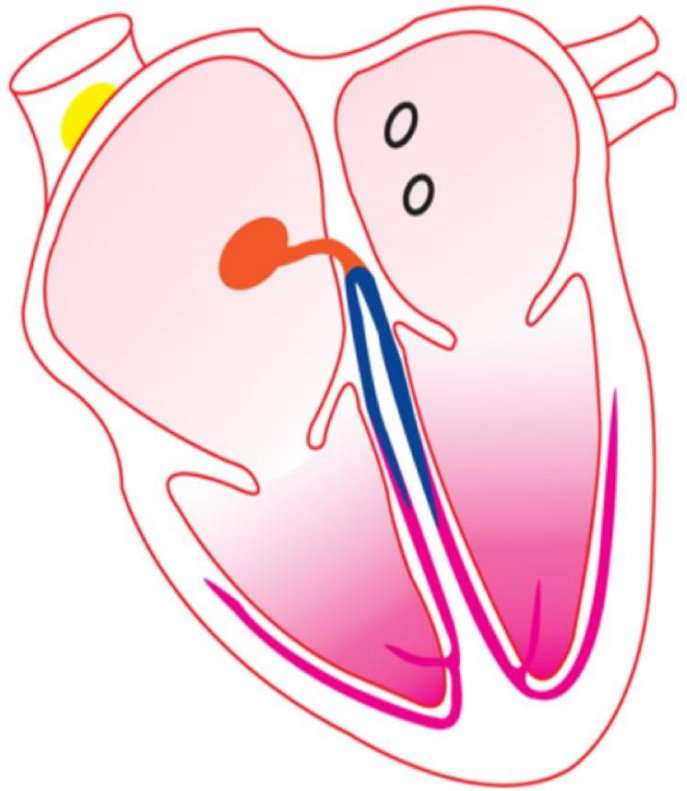


RAE; Upright T V1; large combined praecordial voltages; R V6 - 28mm

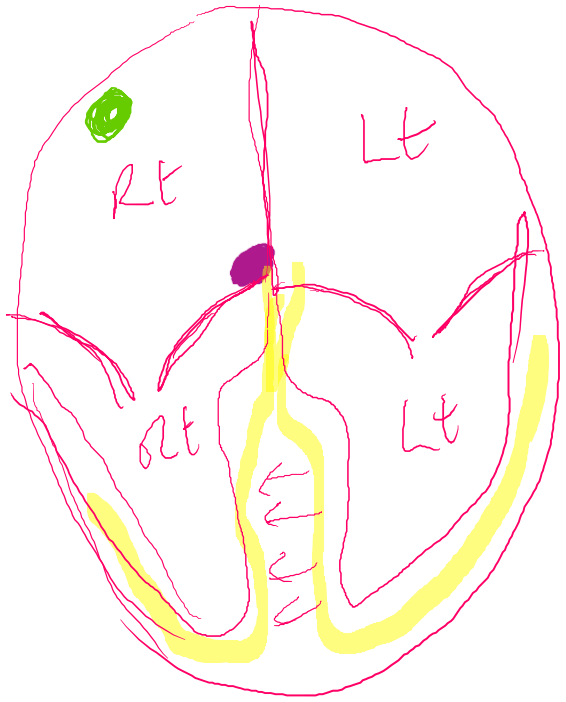

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

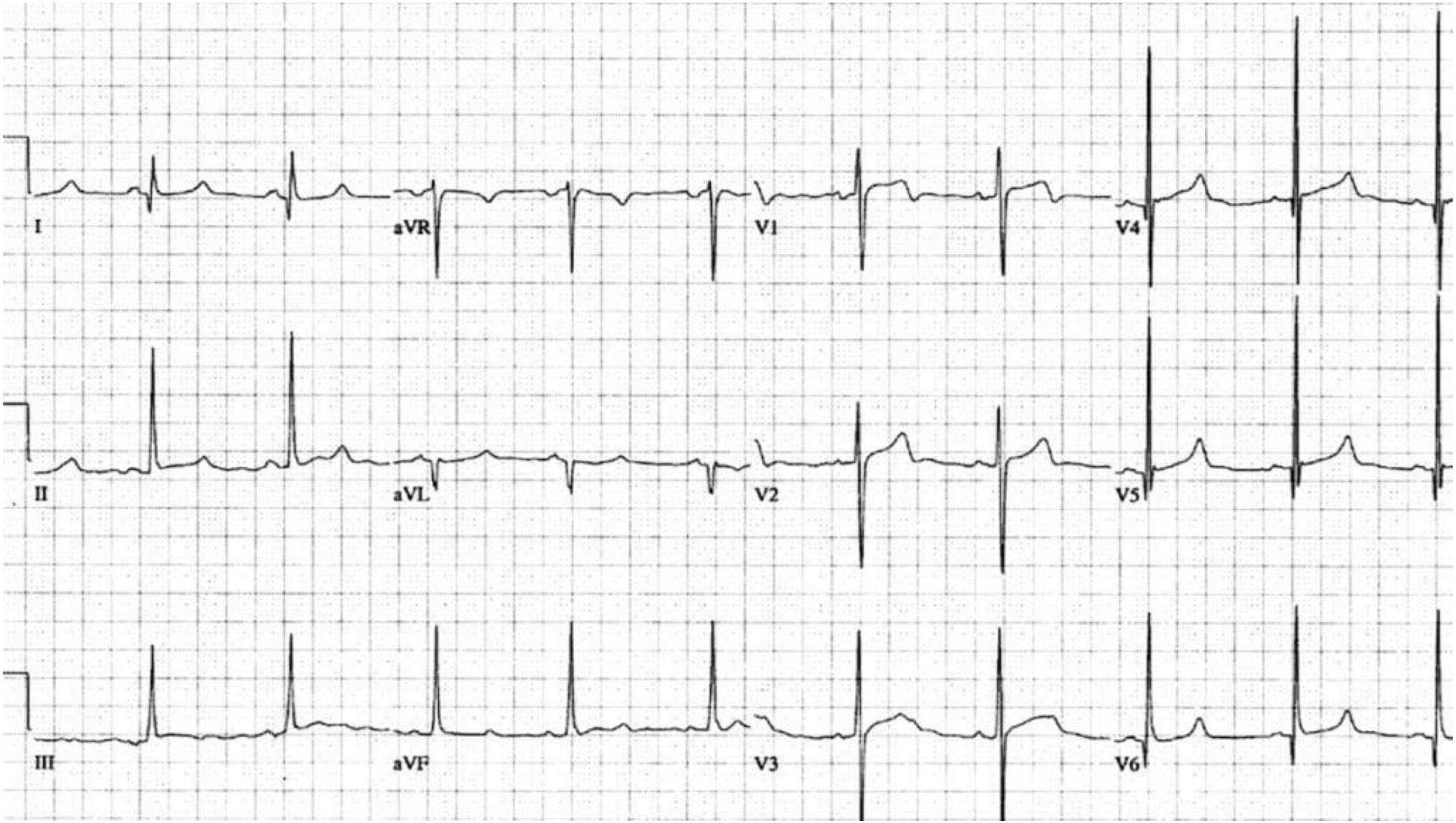
Q-WAVE

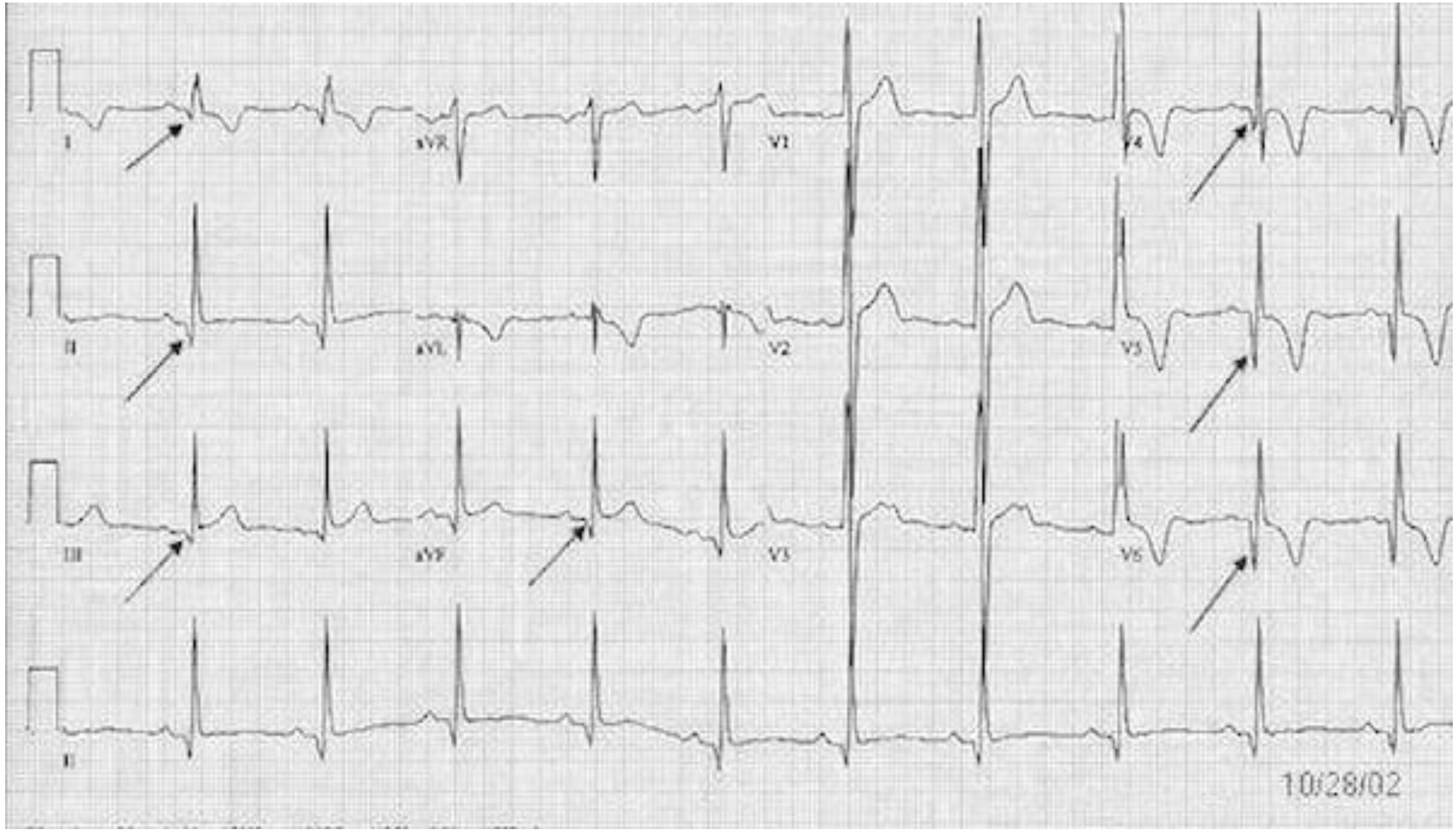
- Any negative deflection that *precedes* an R wave
- L-R depolarisation of the interventricular septum
- Small ‘septal’ Q waves are typically seen in the left-sided leads (I, aVL, V5 and V6)

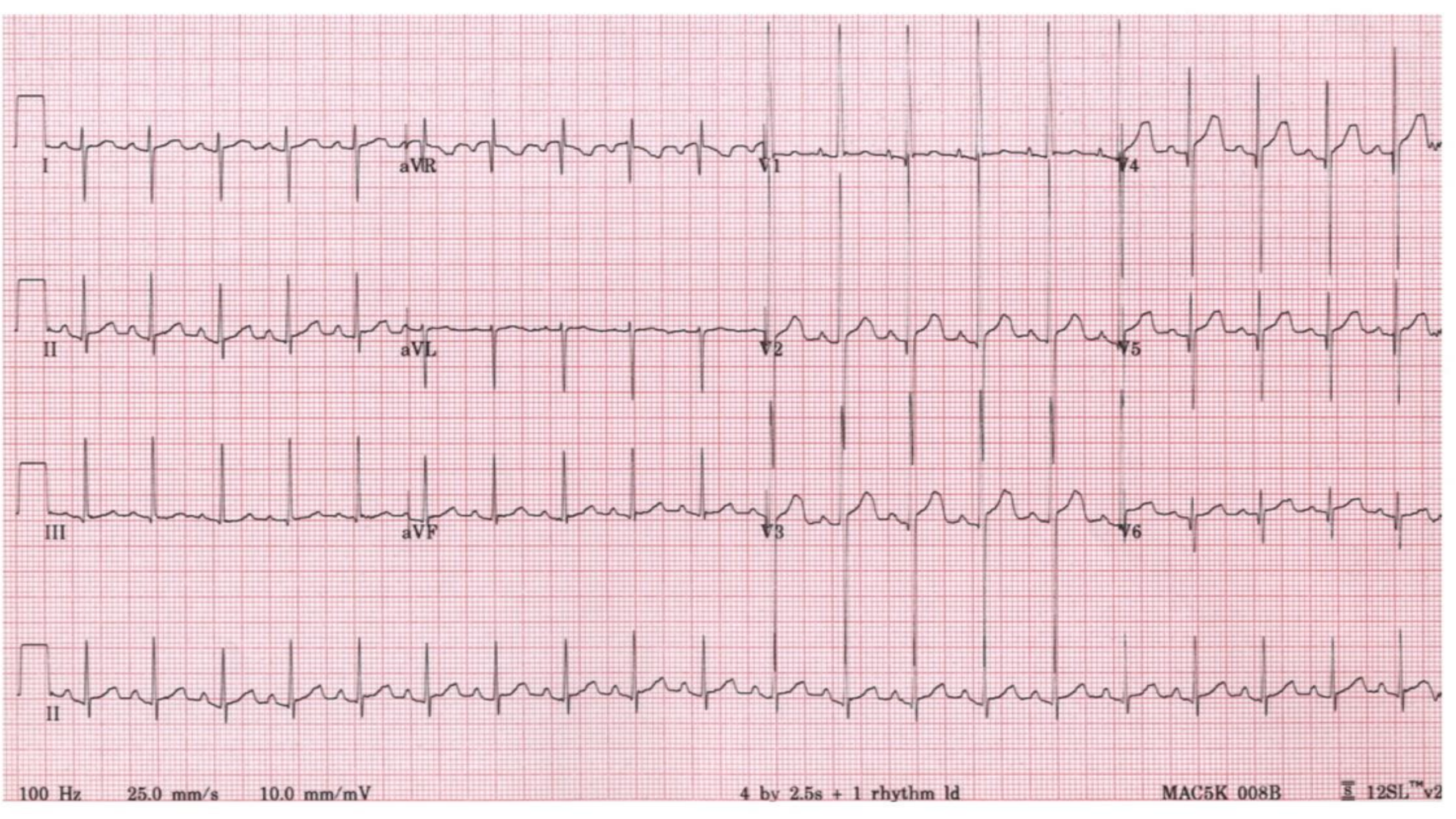


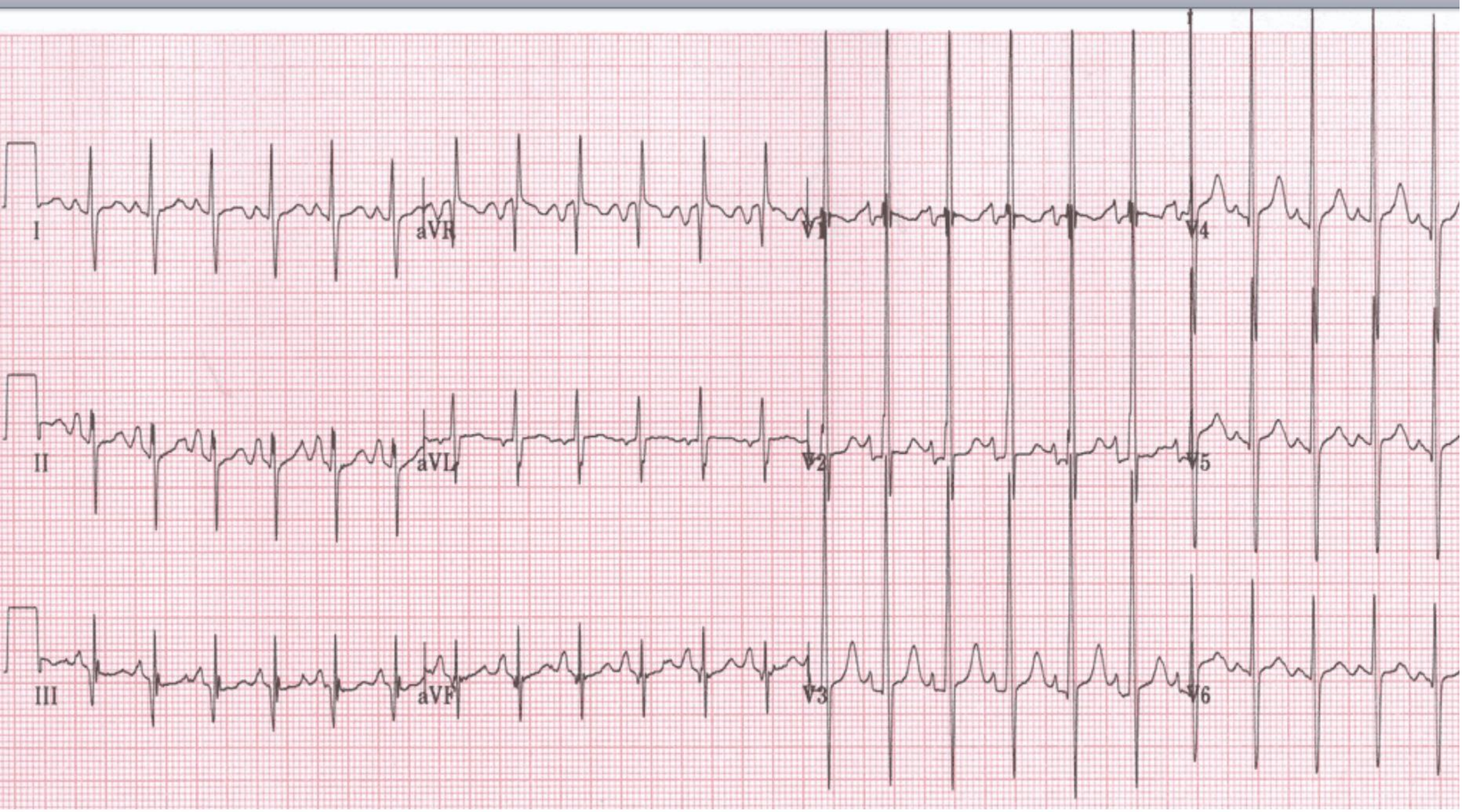
AXIS

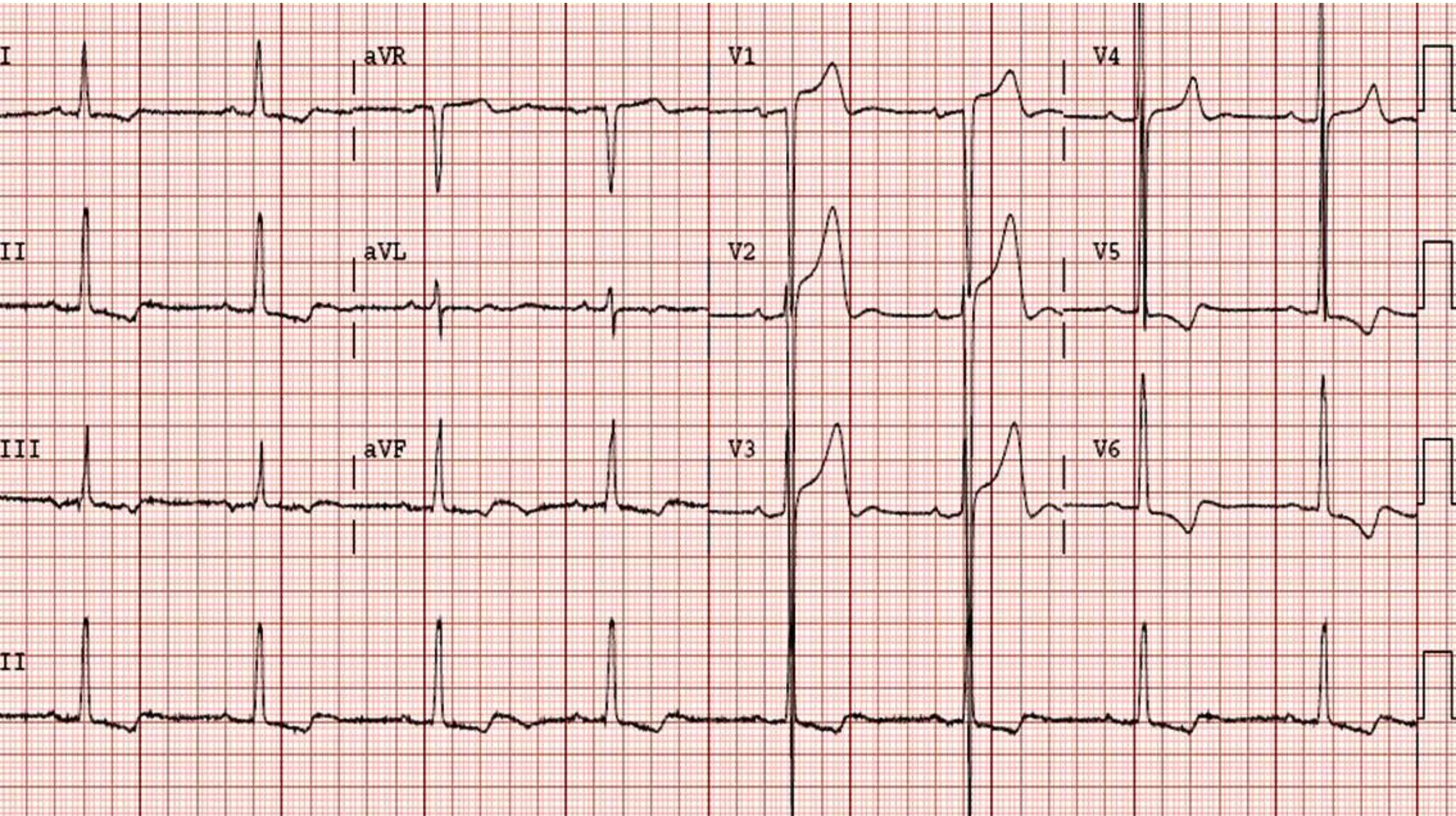


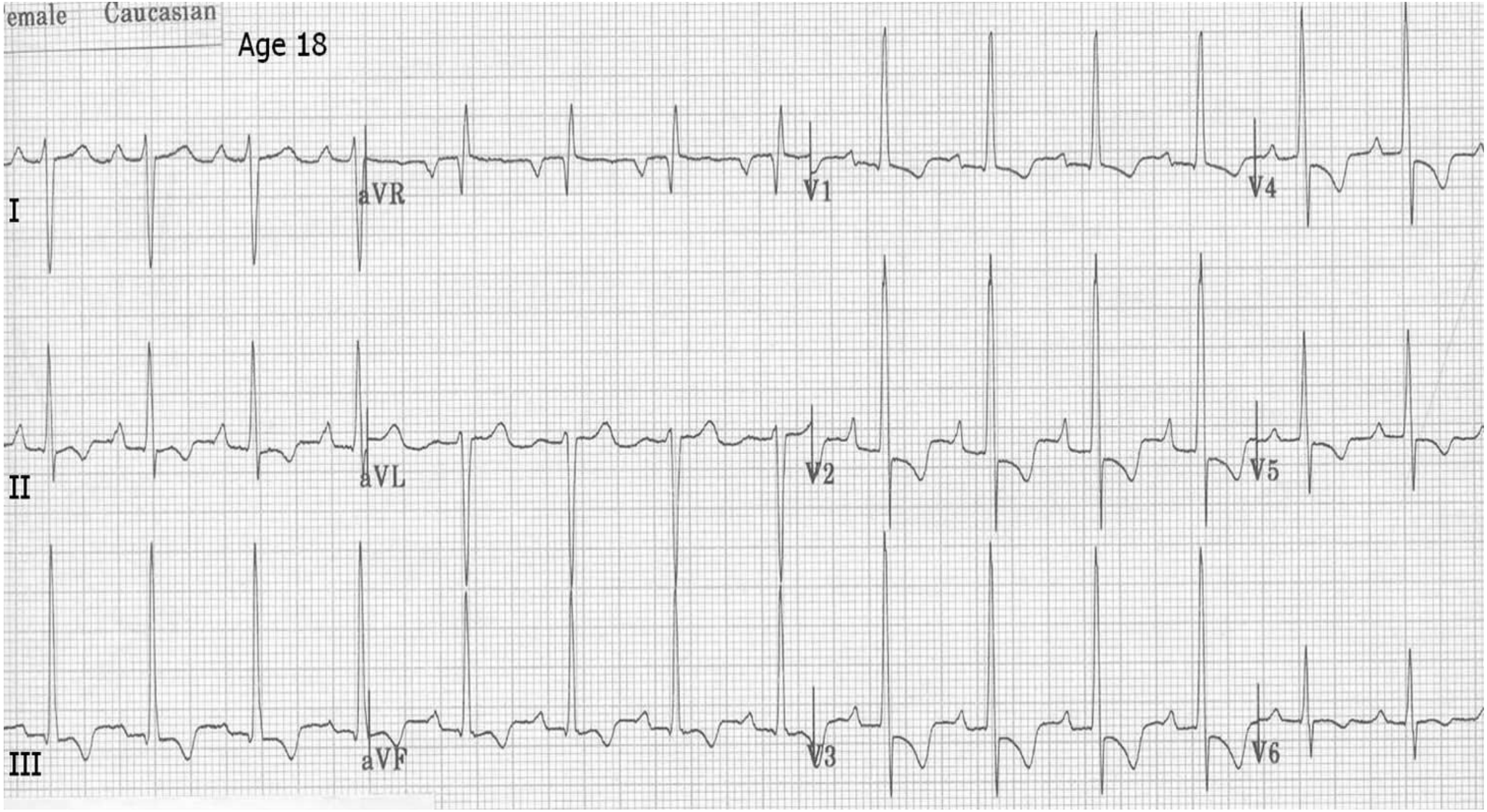

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

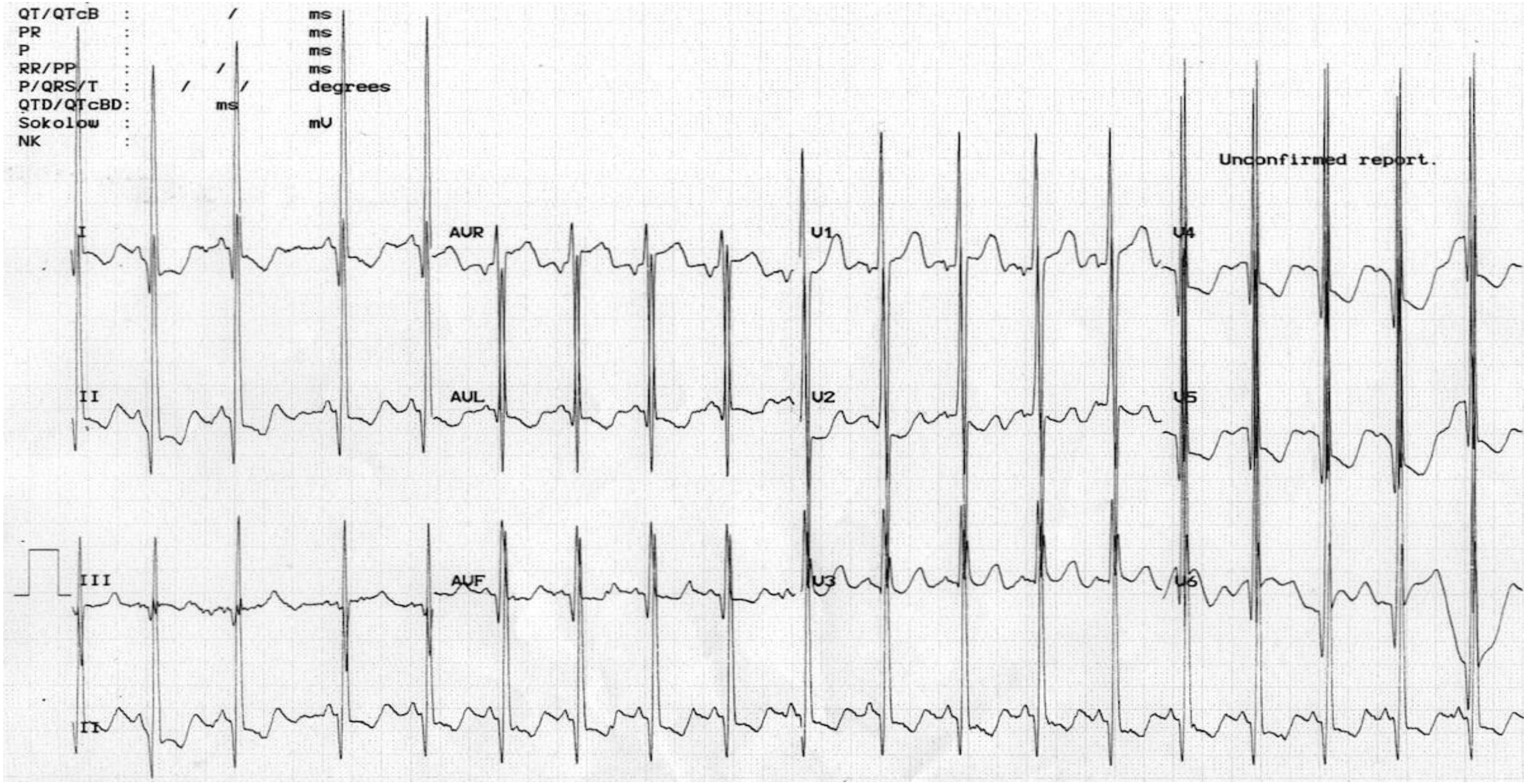

I
aVR
V1
II
aVL
V2
III
aVF
V3
II
10/28/02

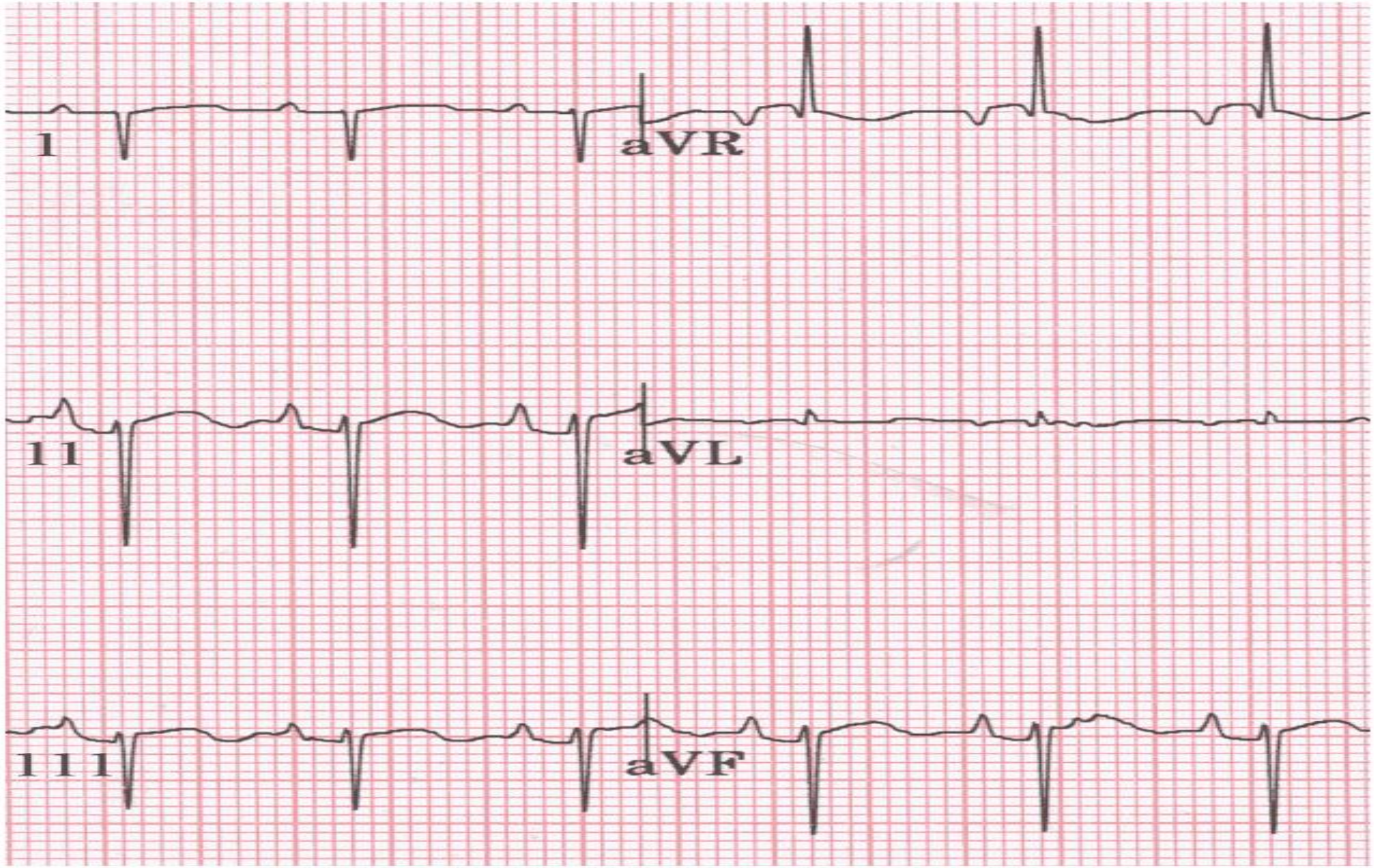

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
100 Hz
25.0 mm/s
10.0 mm/mV
4 by 2.5s + 1 rhythm ld
MAC5K 008B
12SL™v2


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


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


emale Caucasian
Age 18
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6


QT/QTcB : / ms
PR : ms
P : ms
RR/PP : / ms
P/QRS/T : / / degrees
QTD/QTcBD: ms
Sokolow : mV
NK :
Unconfirmed report.
I
II
III
AVR
AVL
AVF
V1
V2
V3
V4
V5
V6


I
aVR
II
aVL
III
aVF

Hope its no more a double blind study