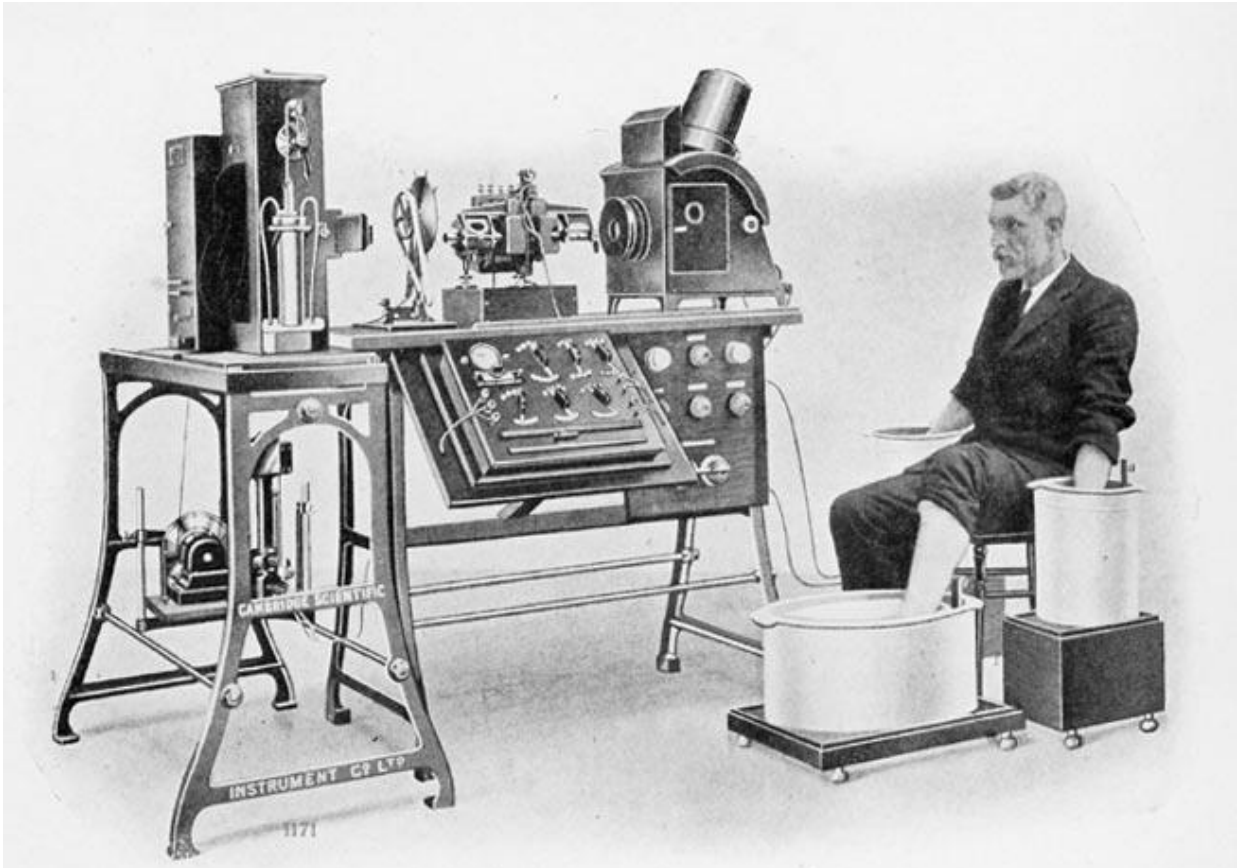
ECG - Basics

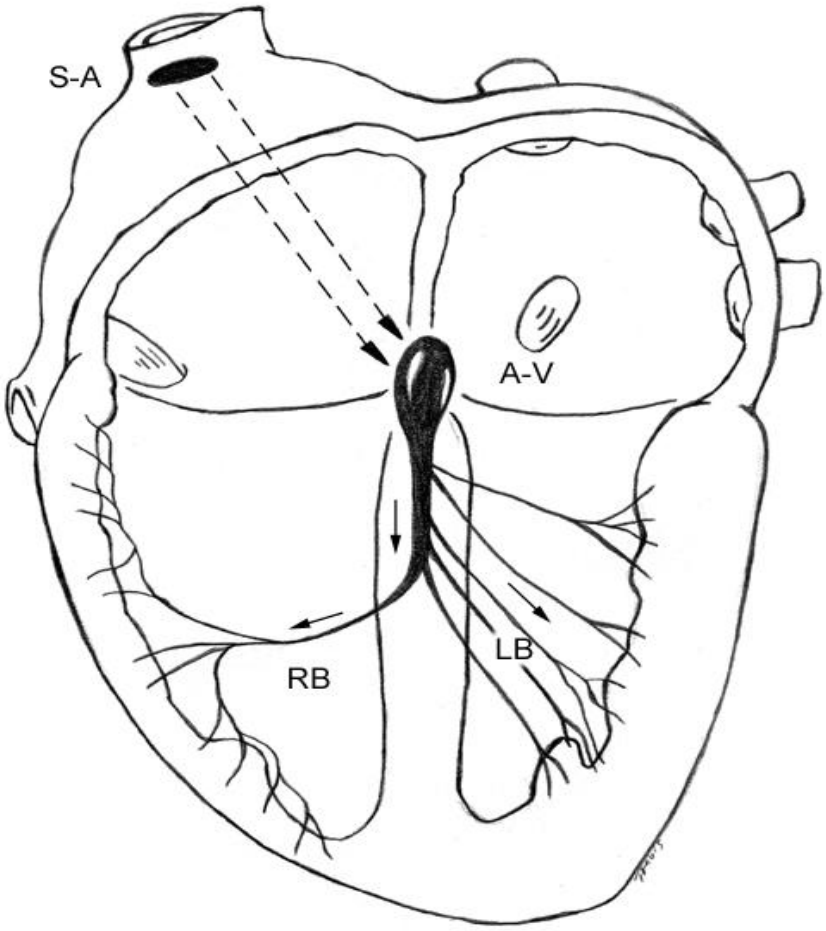
R Menon

Einthoven

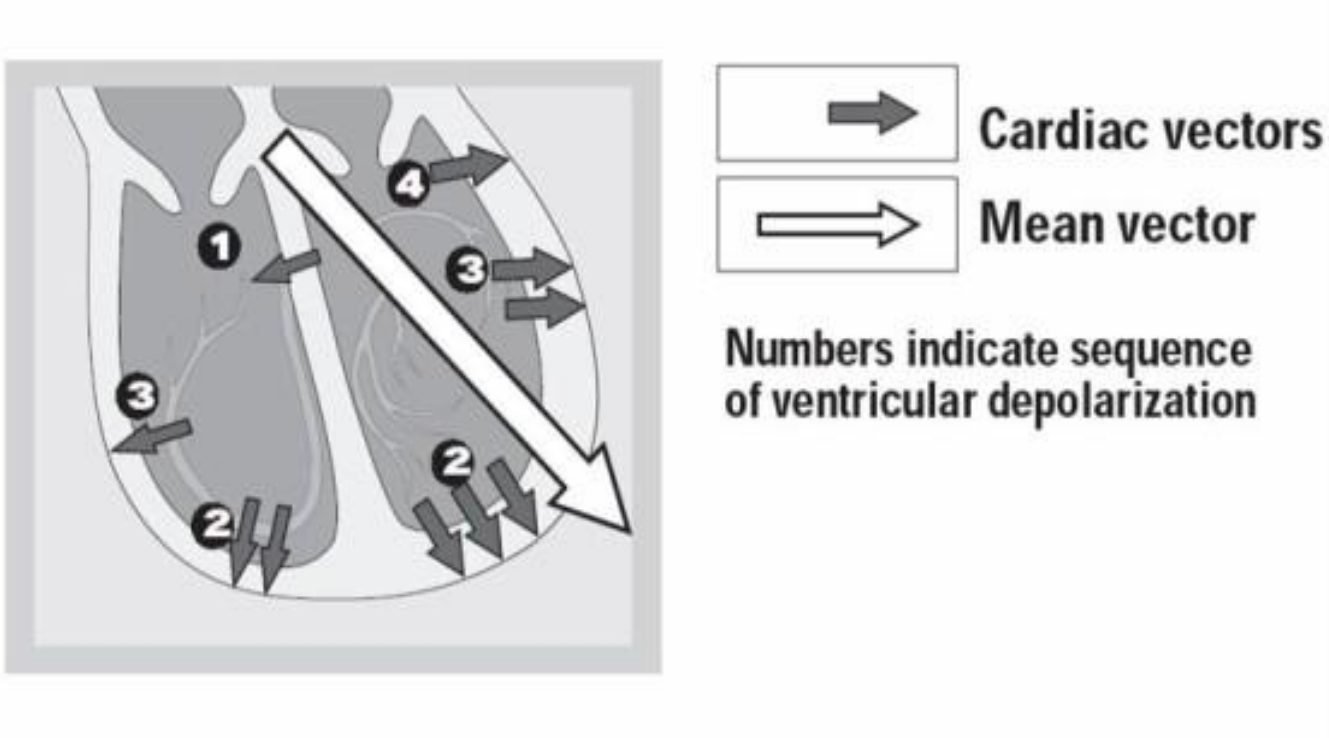


Photograph of a Complete Electrocardiograph, Showing the Manner in which the Electrodes are Attached to the Patient, In this Case the Hands and One Foot Being Immersed in Jars of Salt Solution

Conduction System

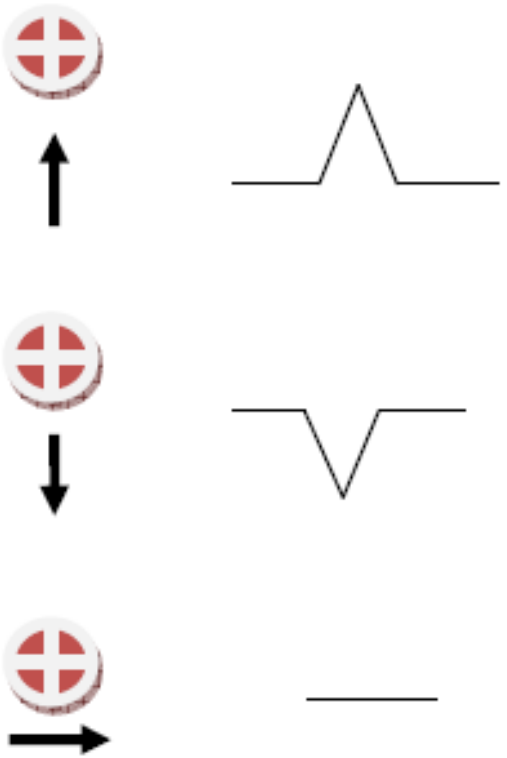


Ventricular depolarisation sequence



Basics

- Electrical current moving toward the positive electrode causes positive deflection.
- Electrical current moving away from the positive electrode causes negative deflection.
- The stronger the current, the stronger the deflection.



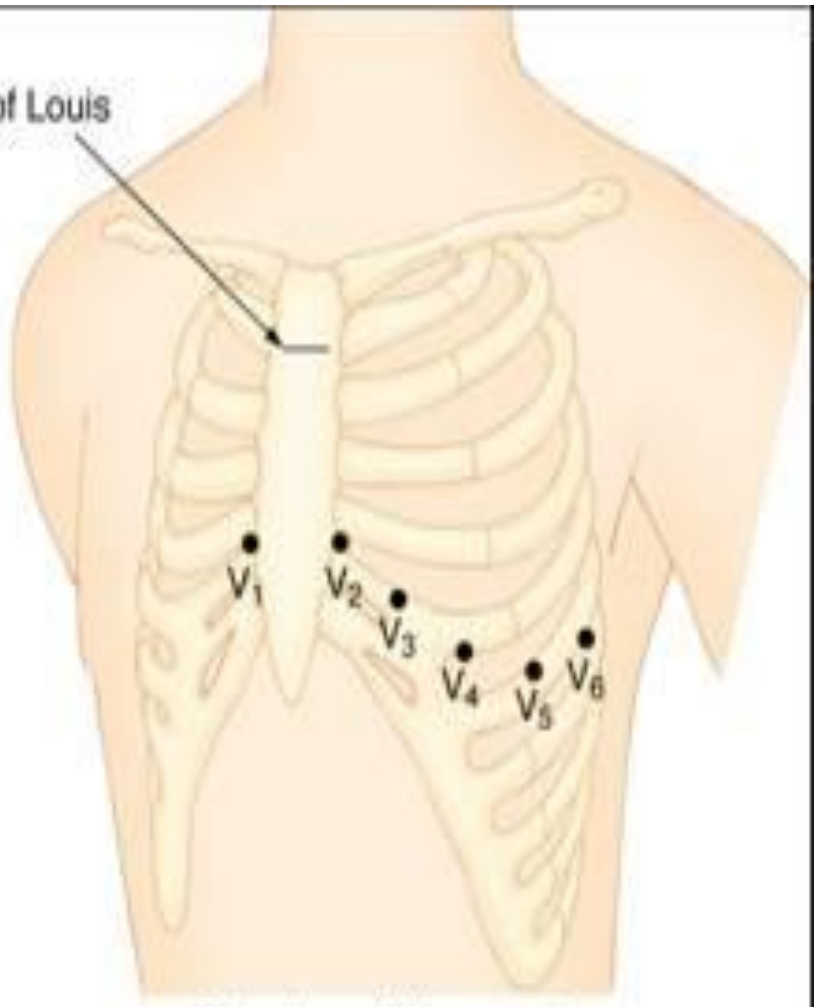
Limb leads - Lead orientation

- Lead I: RA (-) to LA (+)
- Lead II: RA (-) to LF (+)
- Lead III: LA (-) to LF (+)

- Aug. Unipolar
- Lead aVR: RA (+) to [LA & LF] (-) (Rightward)
- Lead aVL: LA (+) to [RA & LF] (-) (Leftward)
- Lead aVF: LF (+) to [RA & LA] (-) (Inferior)

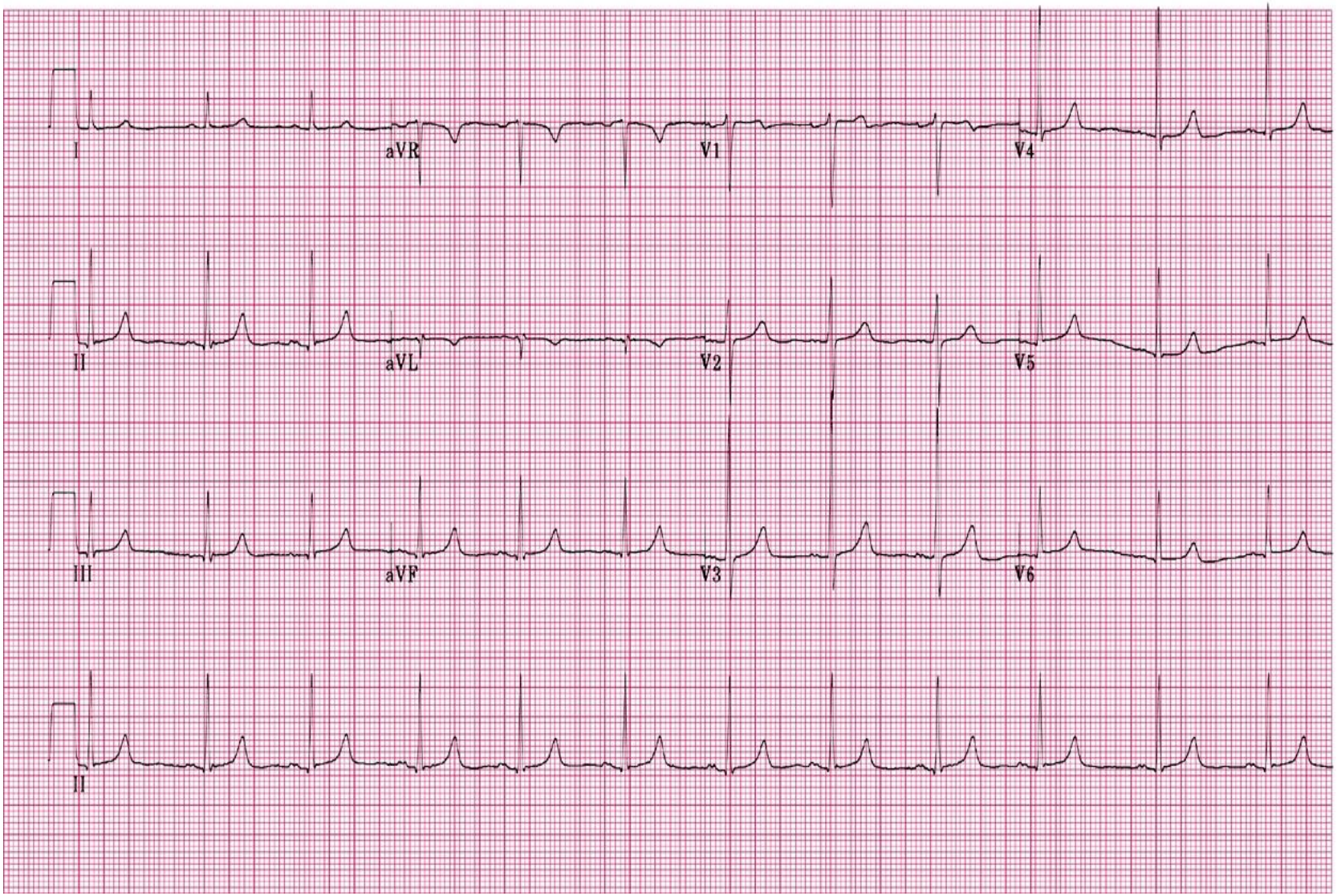
Chest Leads –Positioning

Lead V_1 The electrode is at the fourth intercostal space just to the right of the sternum.
Lead V_2 The electrode is at the fourth intercostal space just to the left of the sternum.
Lead V_3 The electrode is at the line midway between leads V_2 and V_4.
Lead V_4 The electrode is at the midclavicular line in the fifth interspace.
Lead V_5 The electrode is at the anterior axillary line at the same level as lead V_4.
Lead V_6 The electrode is at the midaxillary line at the same level as lead V_4.

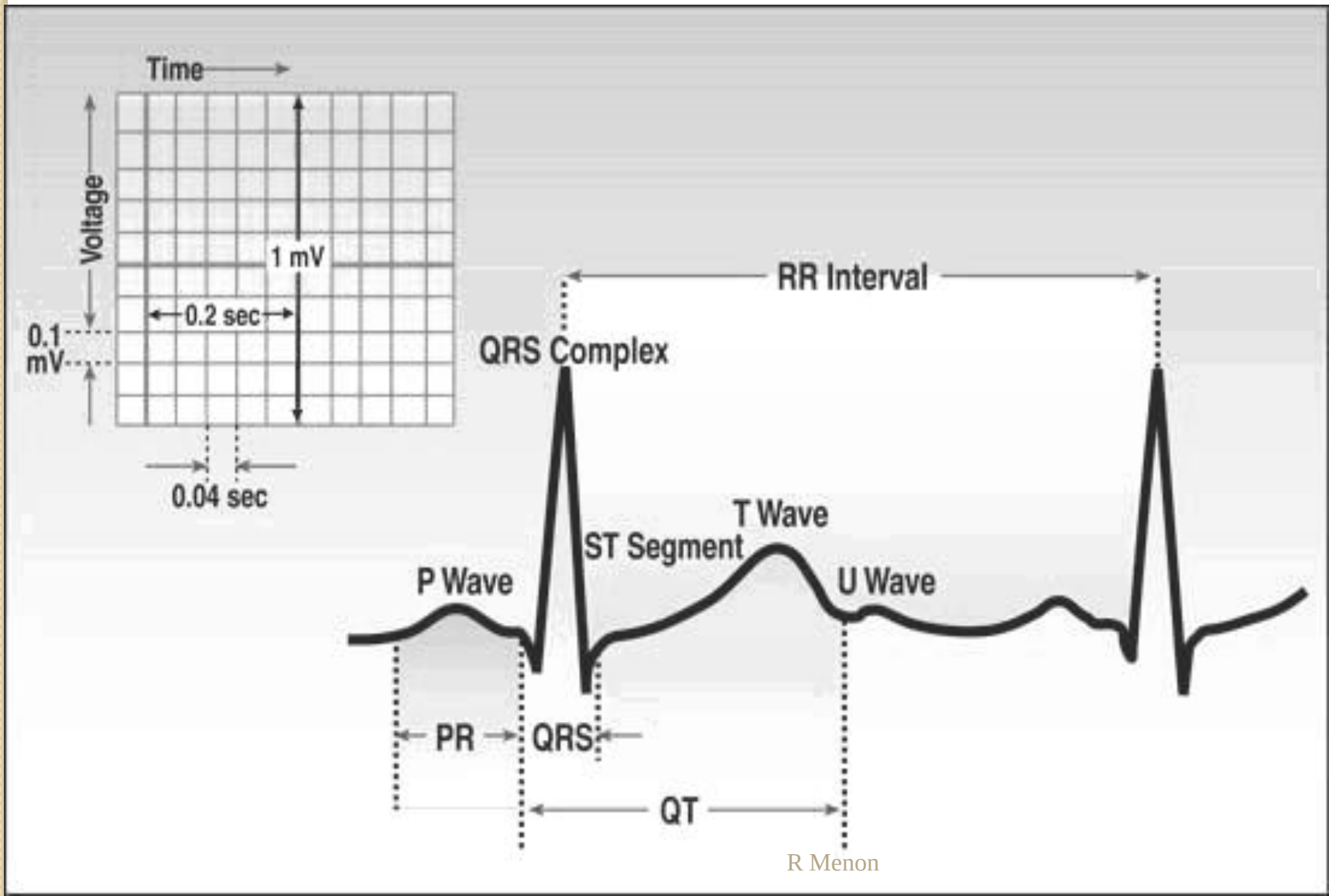


Chest Lead Placement

Normal



Waves and intervals



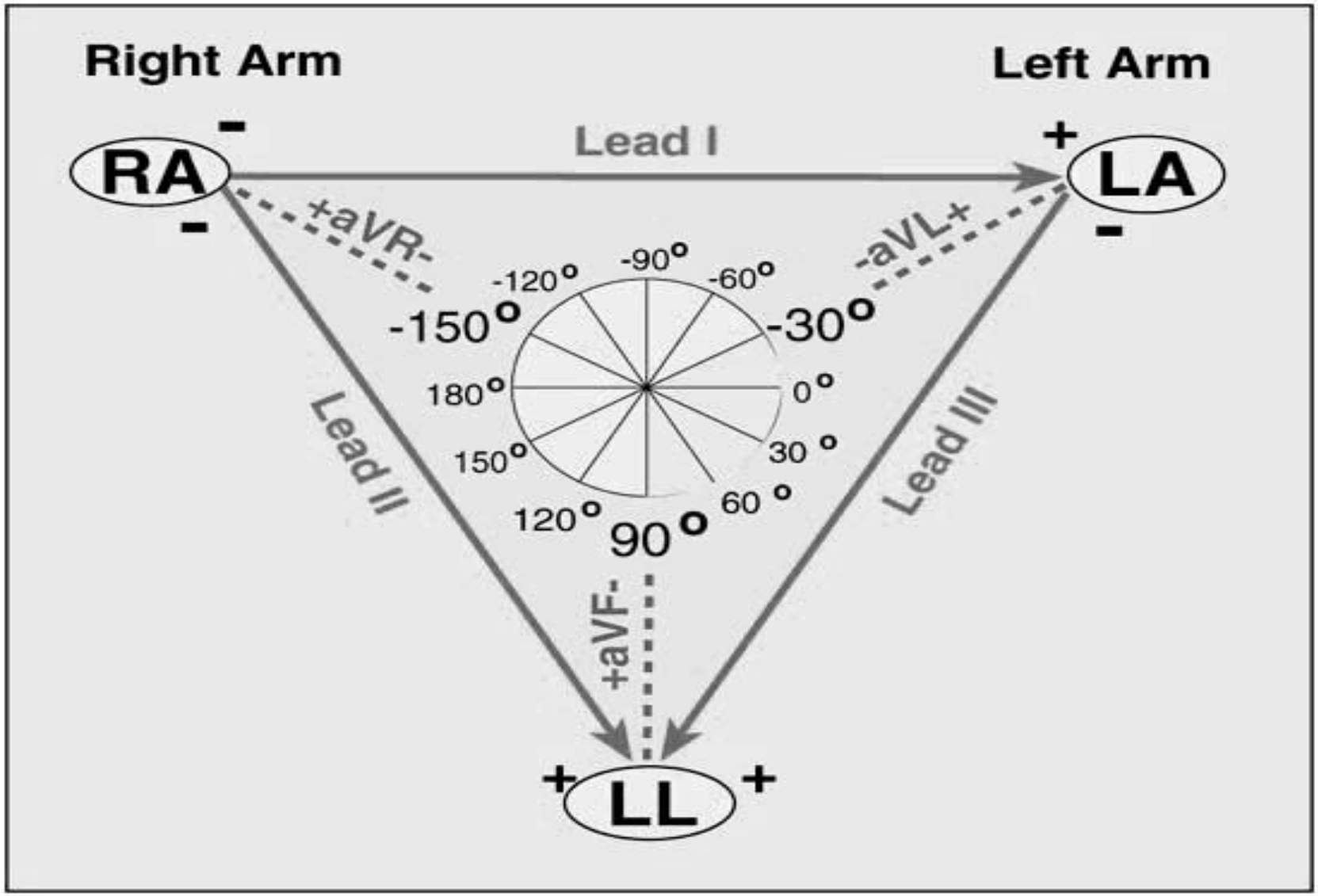
Waves and significance

- P wave: the *sequential* depolarisation of the right and left atria
- QRS complex: right and left ventricular depolarisation.
- ST-T wave: ventricular repolarisation.
- U wave: origin for this wave is not clear - but probably represents "after-depolarisations" in the ventricles, ?papillary muscle depolarisation.
- PR interval: time interval from onset of atrial depolarisation (P wave) to onset of ventricular depolarisation (QRS complex).
- QRS duration: duration of ventricular muscle depolarisation.
- QT interval: duration of ventricular depolarization and repolarisation.
- RR interval: duration of ventricular cycle (an indicator of ventricular rate).
- P interval: duration of atrial cycle (an indicator or atrial rate).

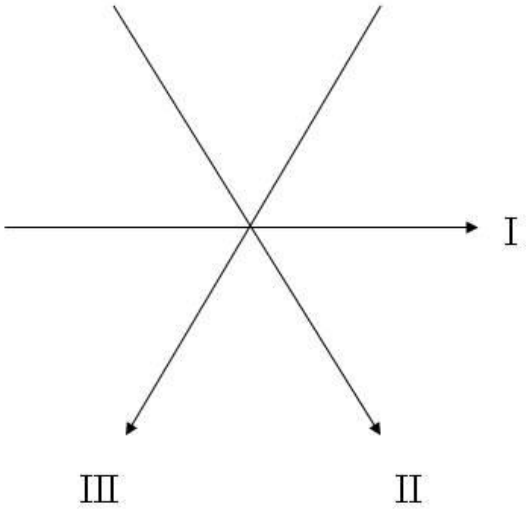
QT and Axis

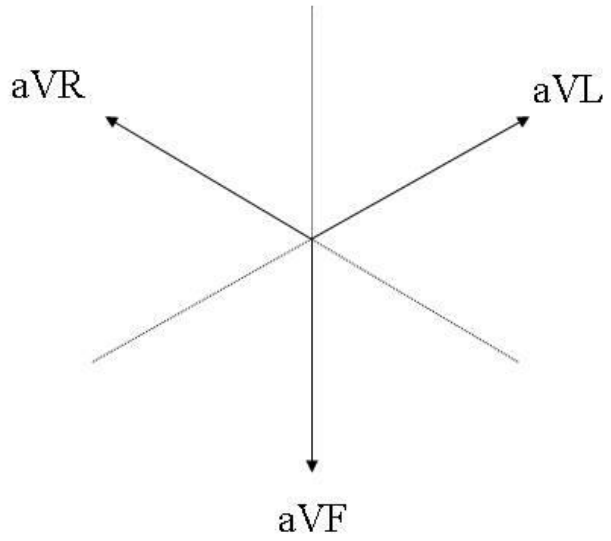
- QT interval – Beginning of QRS to end of T wave. Corrected for heart rate –
- Bazett's formula QT/√RR *in seconds*. N< 440 – 480ms.
- QRS axis - Normal range - -30^{o} to $+100^{o}$.
- Axis Deviation –
- Left axis deviation (i.e., superior and leftward) is defined as -30^{o} to -90^{o}, and
- Right axis deviation (i.e., inferior and rightward) is defined as $+100^{o}$ to $+150^{o}$.
- Extreme axis deviation (NW axis) is the remaining bit.
- By convention axes above the horizontal are negative and those below are positive. (See diagram below)

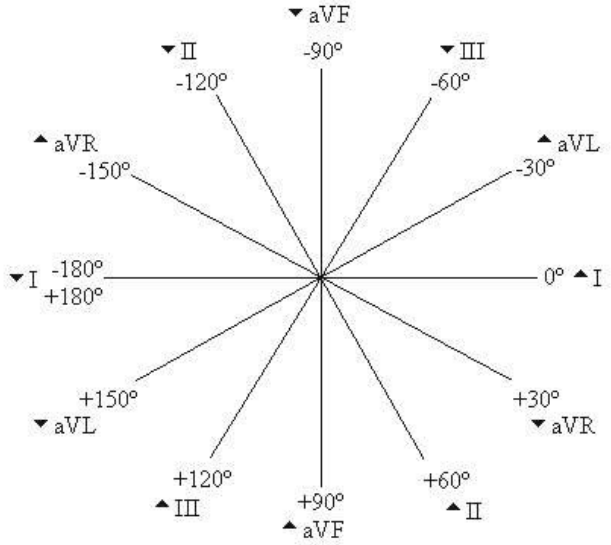
Hex-axial system and leads



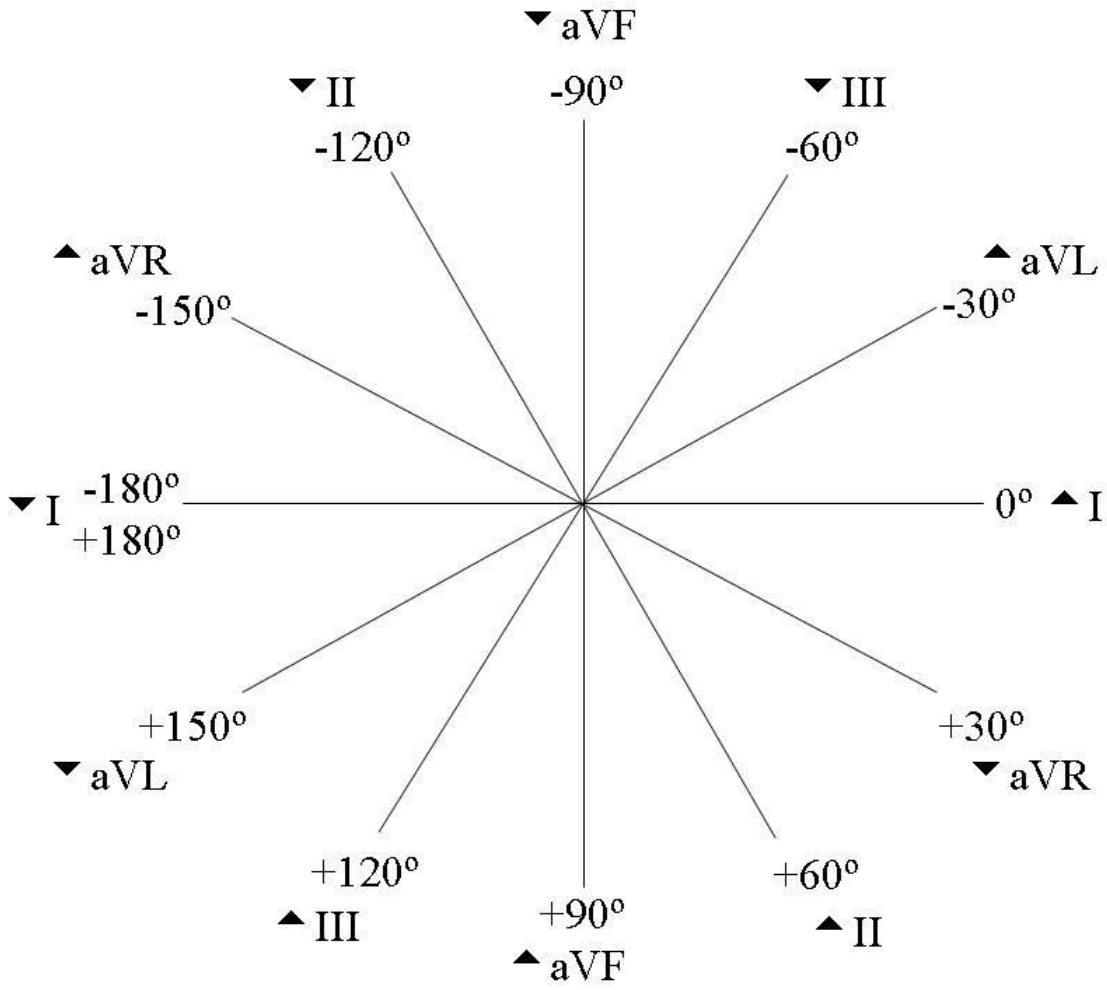
Hex-axial system







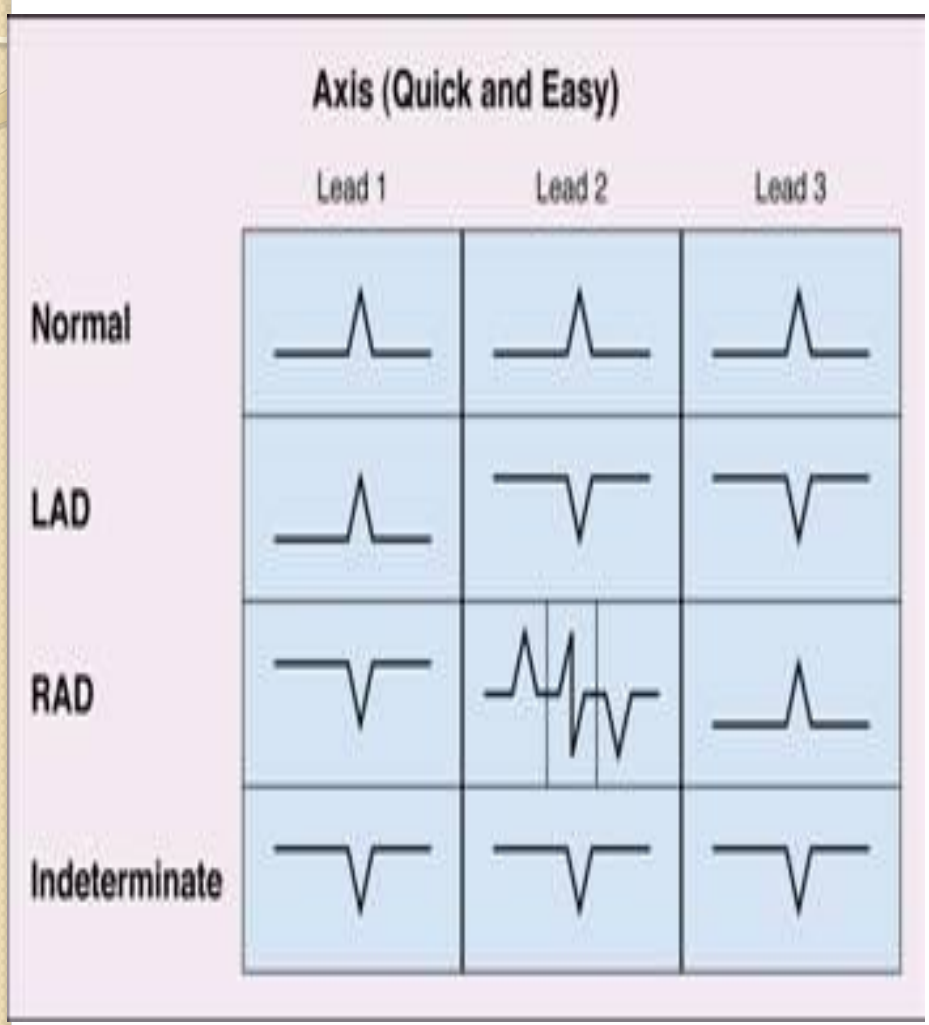
Another way


aVF
-90°
II
-120°
III
-60°
aVR
-150°
aVL
-30°
I
-180°
+180°
0°
I
+150°
aVL
+30°
aVR
+120°
III
+90°
aVF
+60°
II

QRS Axis

- First find the *iso-electric* lead if there is one; i.e., the lead with equal forces in the positive and negative direction. Usually this is the lead with the smallest QRS deflection.
- The QRS axis is *perpendicular* to that lead's orientation (see diagram above). With an error margin of +/- 30. To fine tune, look where the main deflection in the iso-electric lead is and adjust 15^0 in that direction.
- Since there are two perpendiculars to each iso-electric lead, chose the perpendicular that best fits the direction of the other ECG leads.
- If there is no iso-electric lead, there are usually *two* leads that are nearly iso-electric, and these are always 30^o apart. Find the perpendiculars for each lead and chose an approximate QRS axis within the 30^o range.
- Occasionally each of the 6 frontal plane leads is small and/or iso-electric. The axis cannot be determined and is called *indeterminate*. This is a normal variant.

Cheat code



- Another cheat
- Use I and aVF
- Both positive = normal
- I +, aVF - = LAD
- I – aVF + = RAD
- Both negative = extreme axis deviation.

Reading an ECG

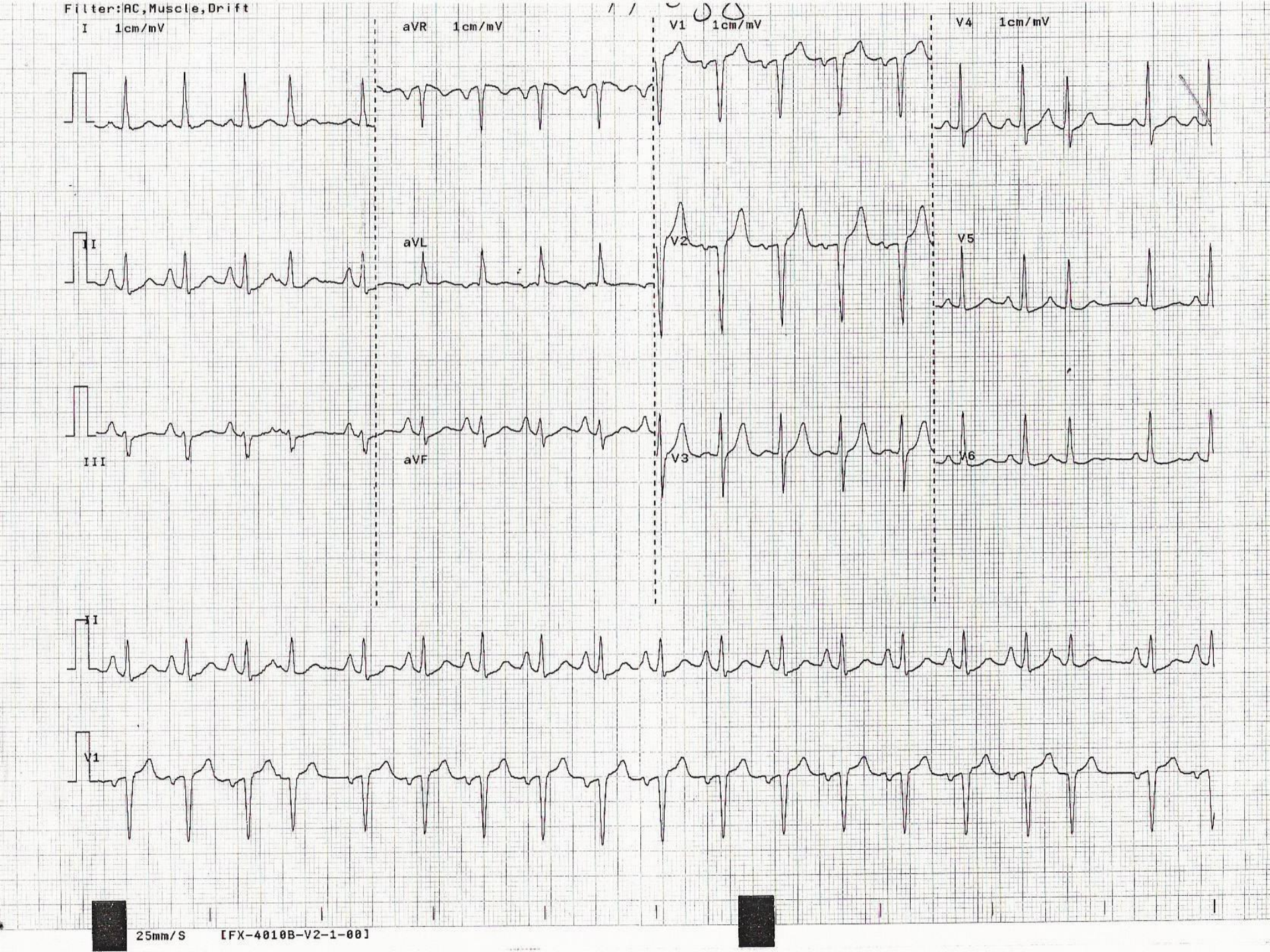
- Measurements – rate, PR, QRS, QT interval
- Rhythm
- Conduction
- Waveform analysis
- *Remember - look for standardisation and paper speed.*

Rhythm analysis

- Vent. rate – 1500/R-R interval in small squares or 300/R-R interval in big squares
- Atrial rate
- Site of origin –SA, A, AV, V
- Regularity of rhythm – reg, reg. Irreg, irreg-irreg
- Cherchez le P
- P and QRS relation
- Ectopics and compensatory intervals
- Impulse conduction – antero, retro, orthodromic etc

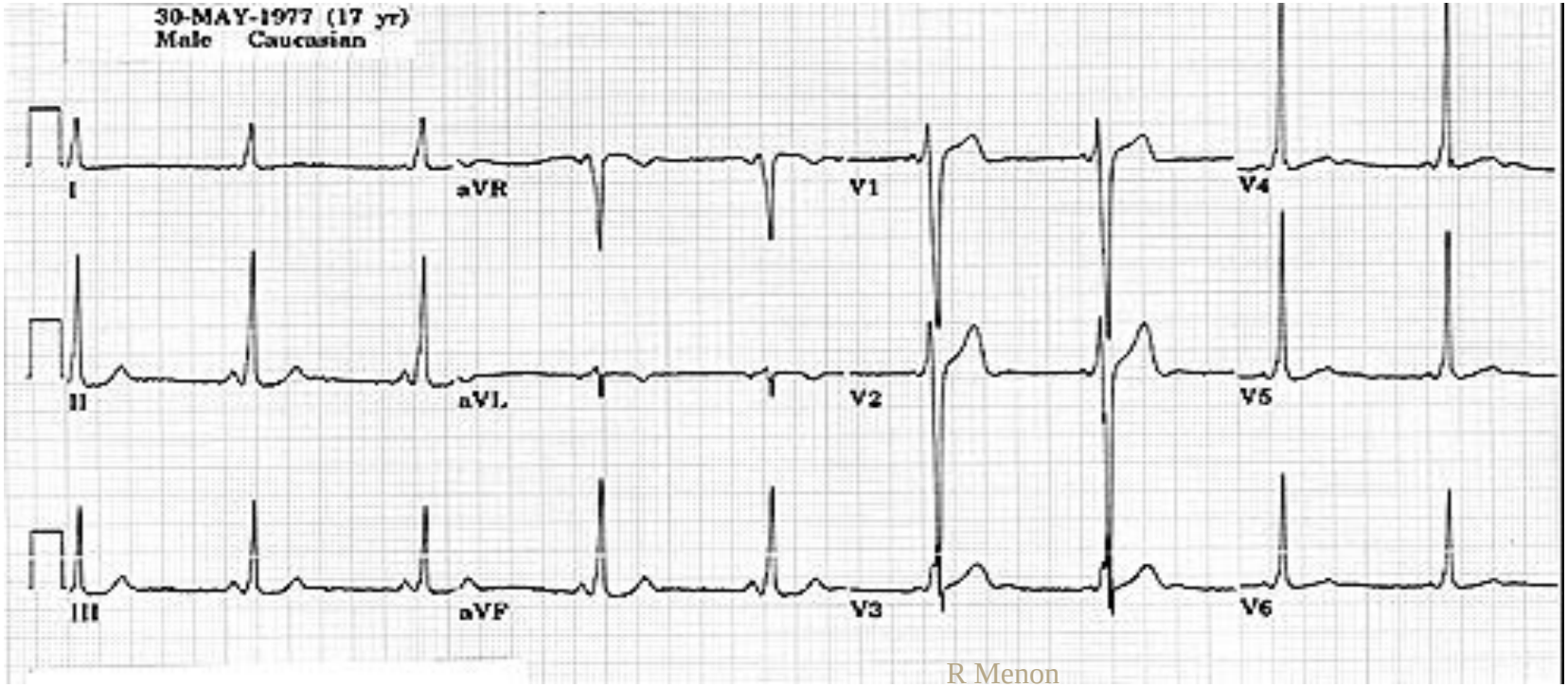
Waveform analysis

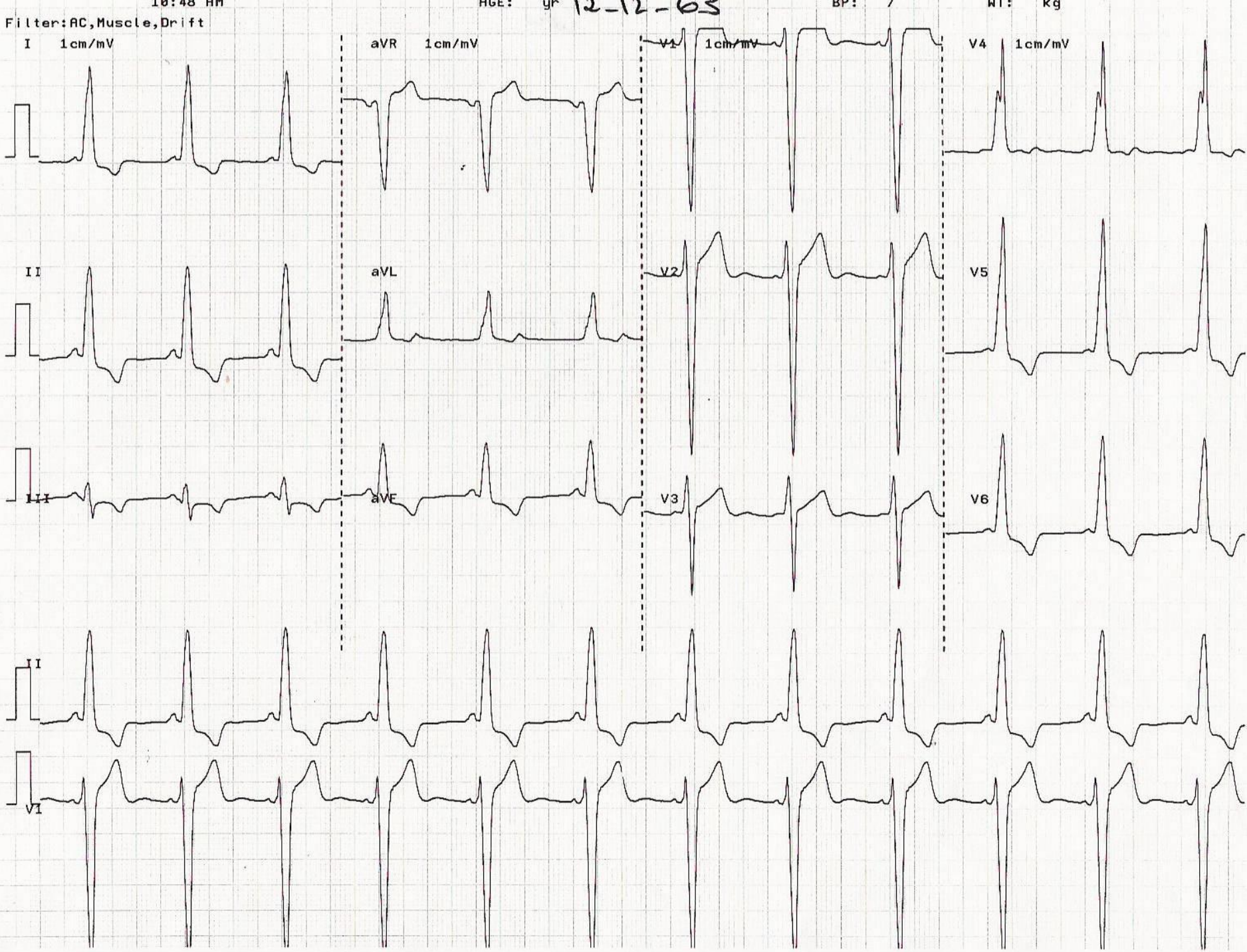
- P waves - seen best in L2 and V1
- P pulmonale, p mitrale
- Criteria for atrial enlargement
- QRS - duration - 80-100mS. >120 mS - bundle branch block.
- T wave – direction, shape, relation to preceding QRS complex.

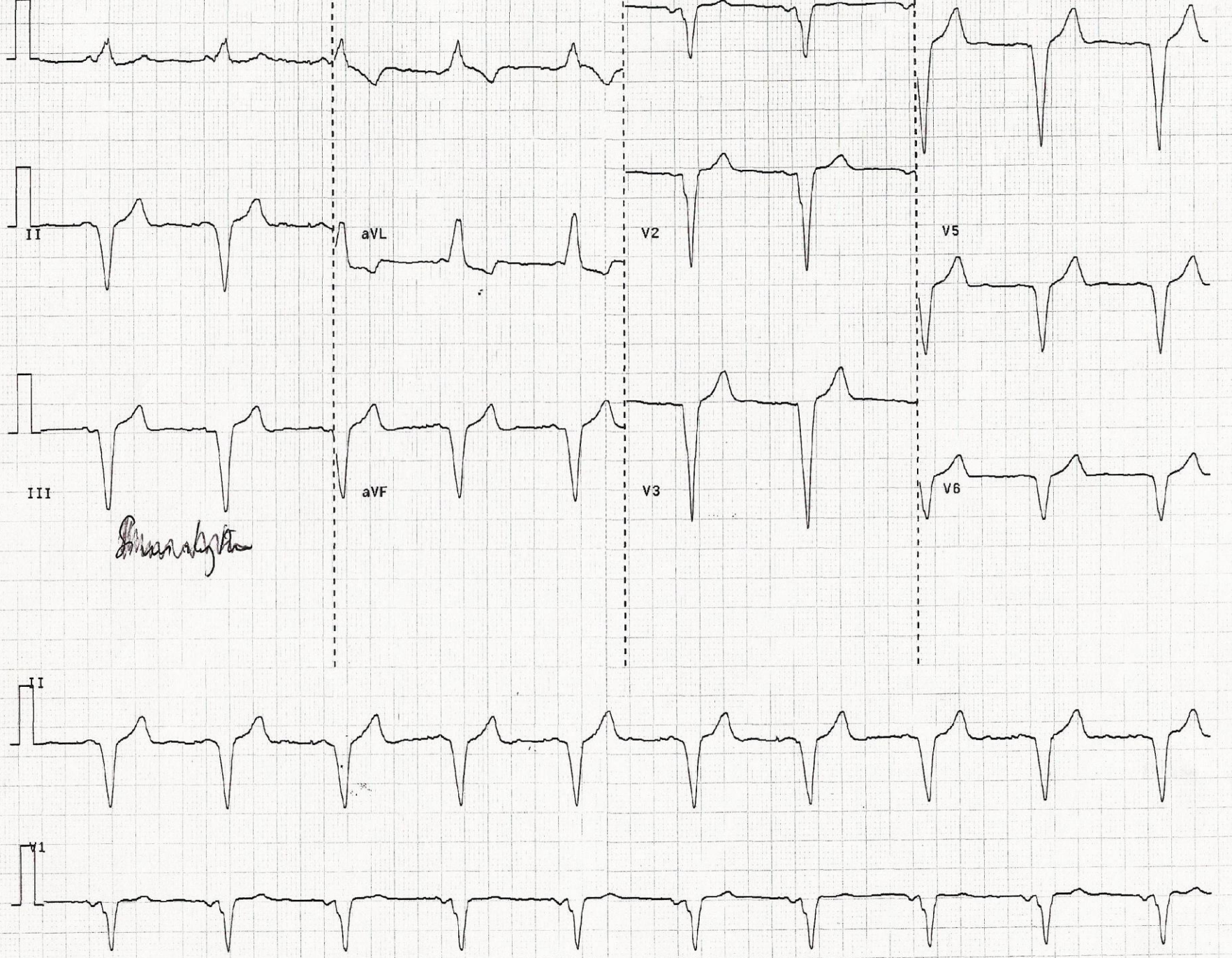

Filter:AC,Muscle,Drift
I 1cm/mV
aVR 1cm/mV
V1 1cm/mV
V4 1cm/mV
II
aVL
V2
V5
III
aVF
V3
V6
II
V1
25mm/S
[FX-4010B-V2-1-00]

Conduction abnormalities

- Wolff-Parkinson-White Syndrome
- Lown-Ganong-Levine Syn.
- Long QT

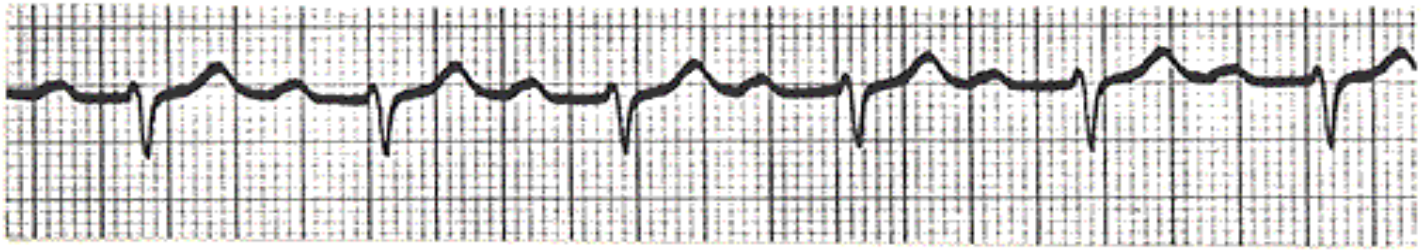



10:48 AM
AGE: yr 12-12-65
BP: /
WT: kg
Filter:AC,Muscle,Drift
I 1cm/mV
aVR 1cm/mV
V1 1cm/mV
V4 1cm/mV
II
aVL
V2
V5
III
aVF
V3
V6
II
V1

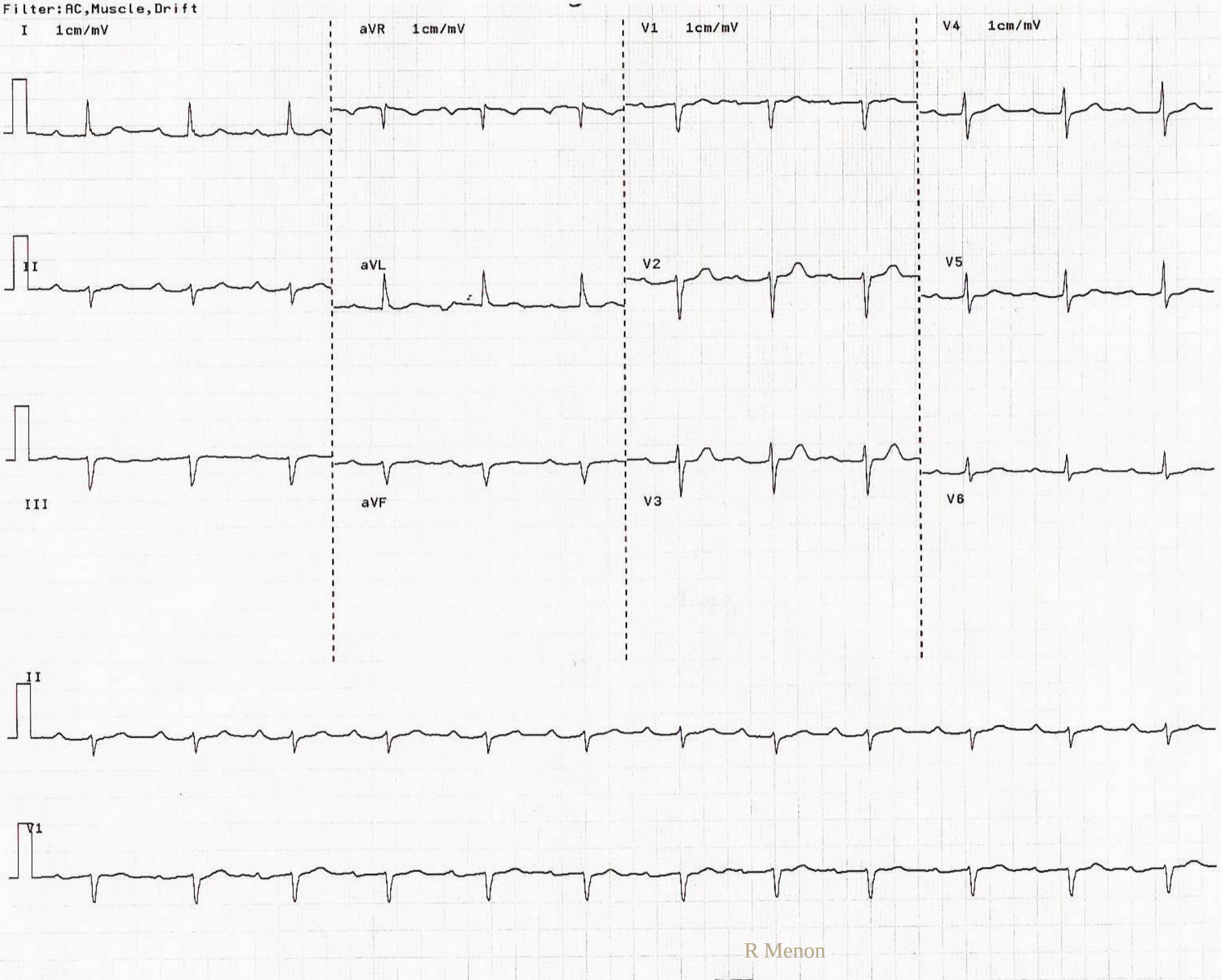

II
aVL
V2
V5
III
aVF
V3
V6
II
V1

Brady-arrythmias

- Sinus bradycardia < 60bpm
- Sinus pause, sinus arrest
- Sino-atrial block
- First degree heart block
- Type 1 and Type 2 second degree block
- Complete heart block
- Sick sinus syndrome



1st degree AV block (PR = 280 ms)


Filter:AC,Muscle,Drift
I 1cm/mV
aVR 1cm/mV
V1 1cm/mV
V4 1cm/mV
II
aVL
V2
V5
III
aVF
V3
V6
II
V1

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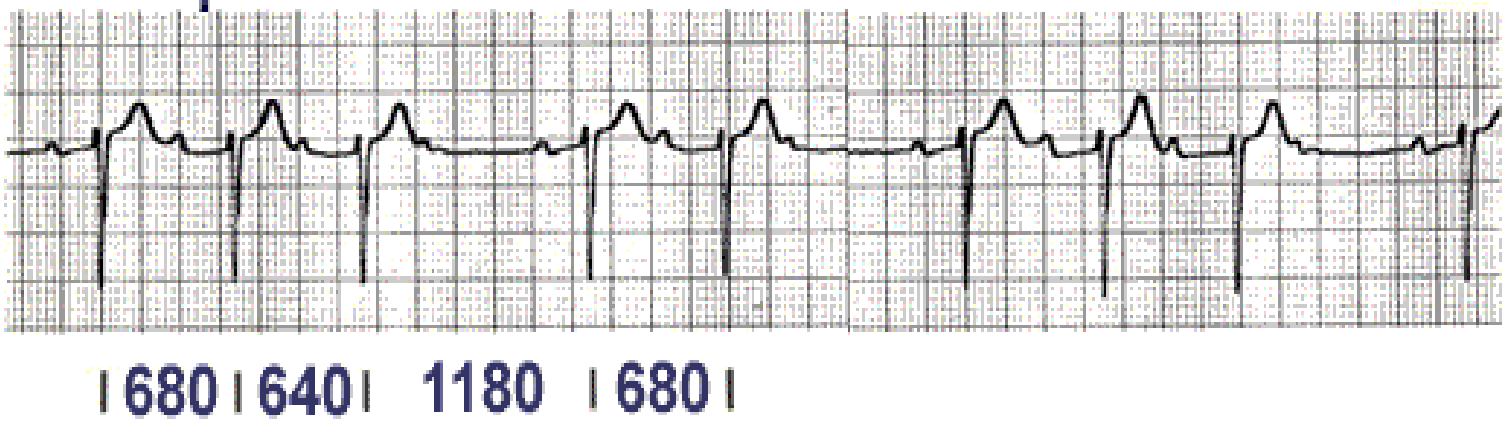
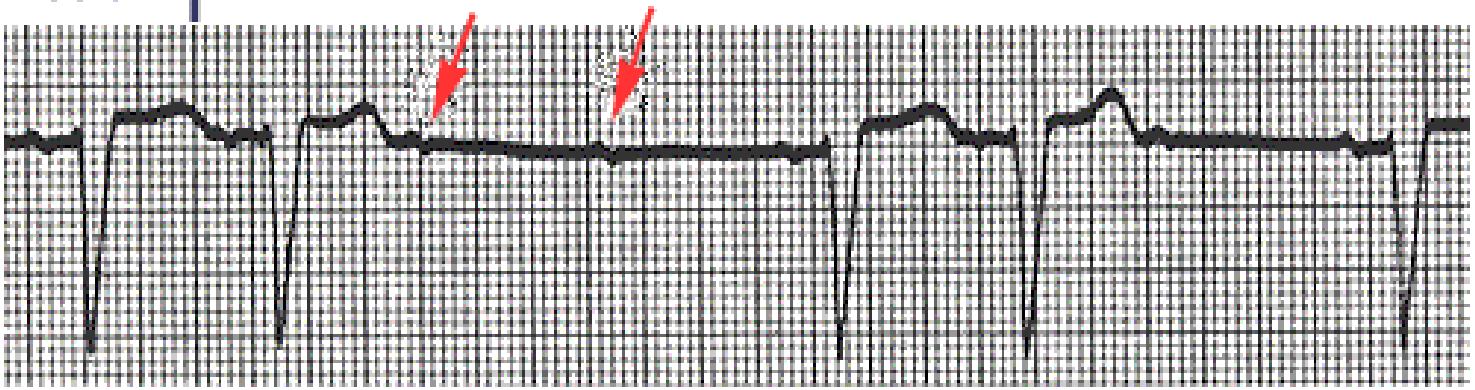
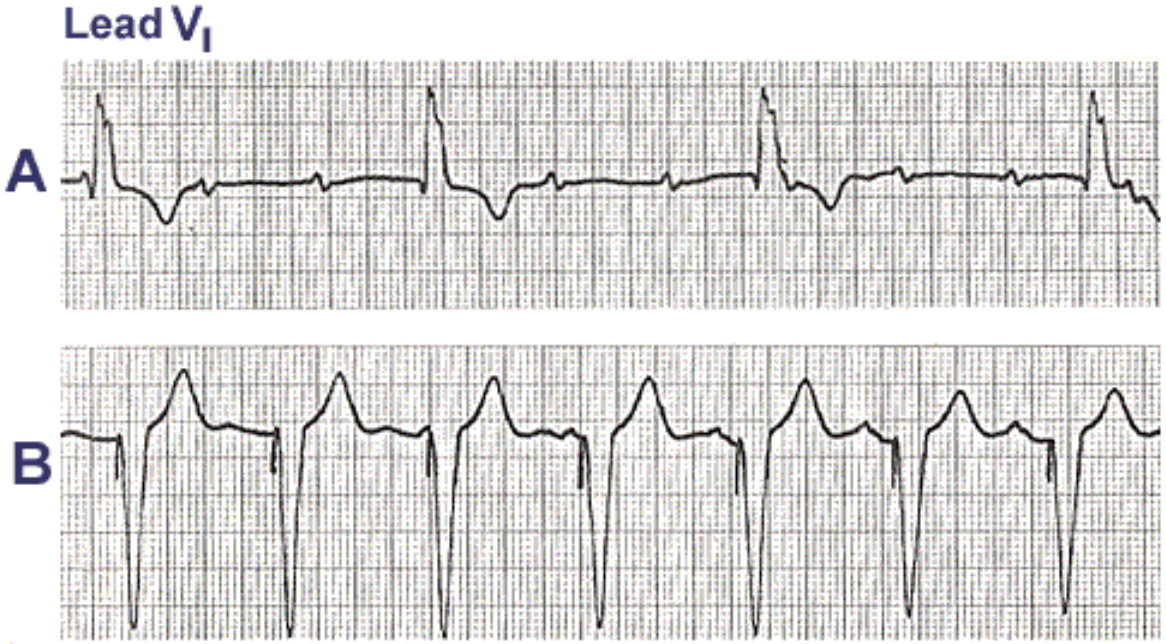
Lead V_1 "Classic Wenckebach"

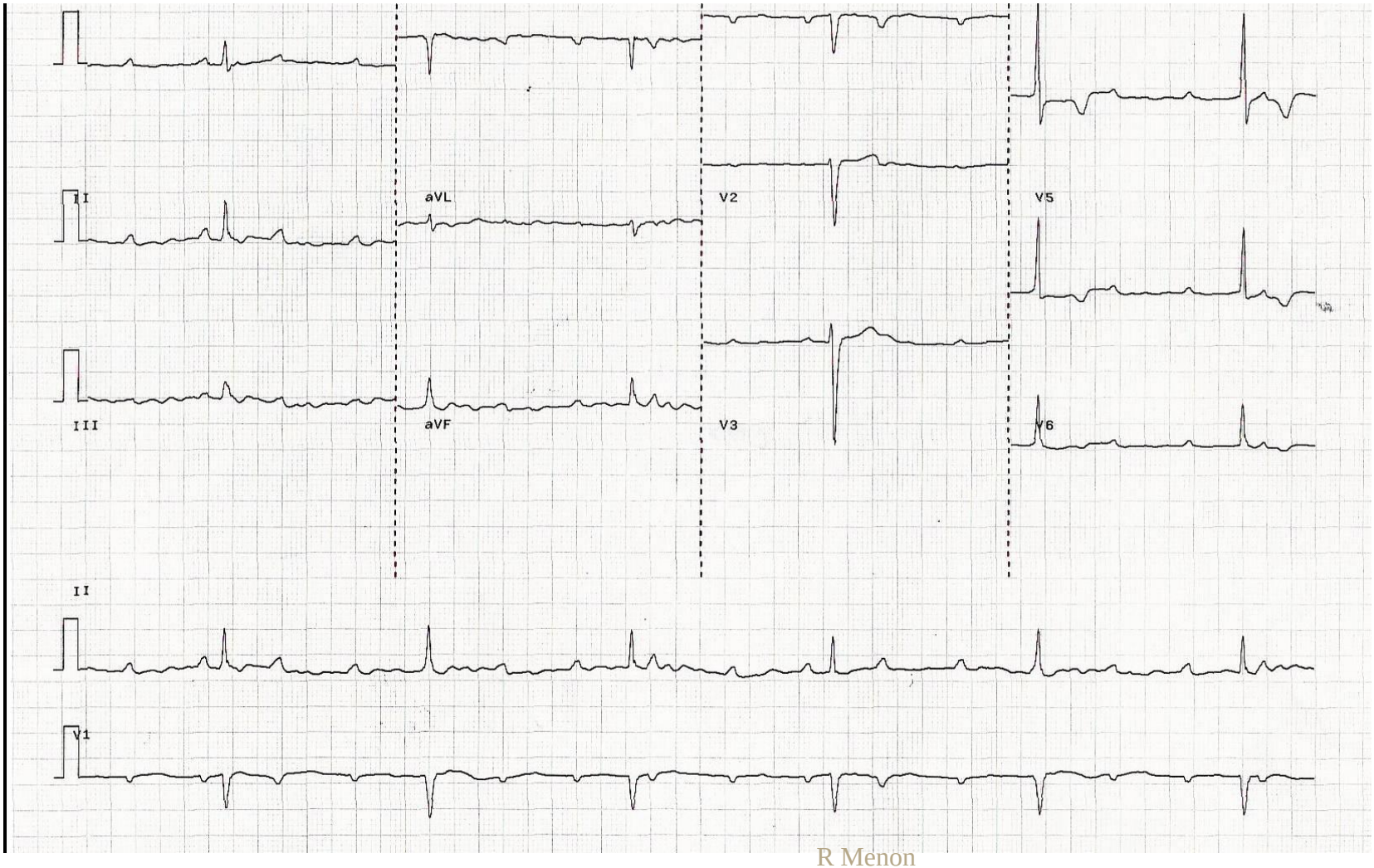


Lead V_1




Lead V_1
A
B

Complete heart block



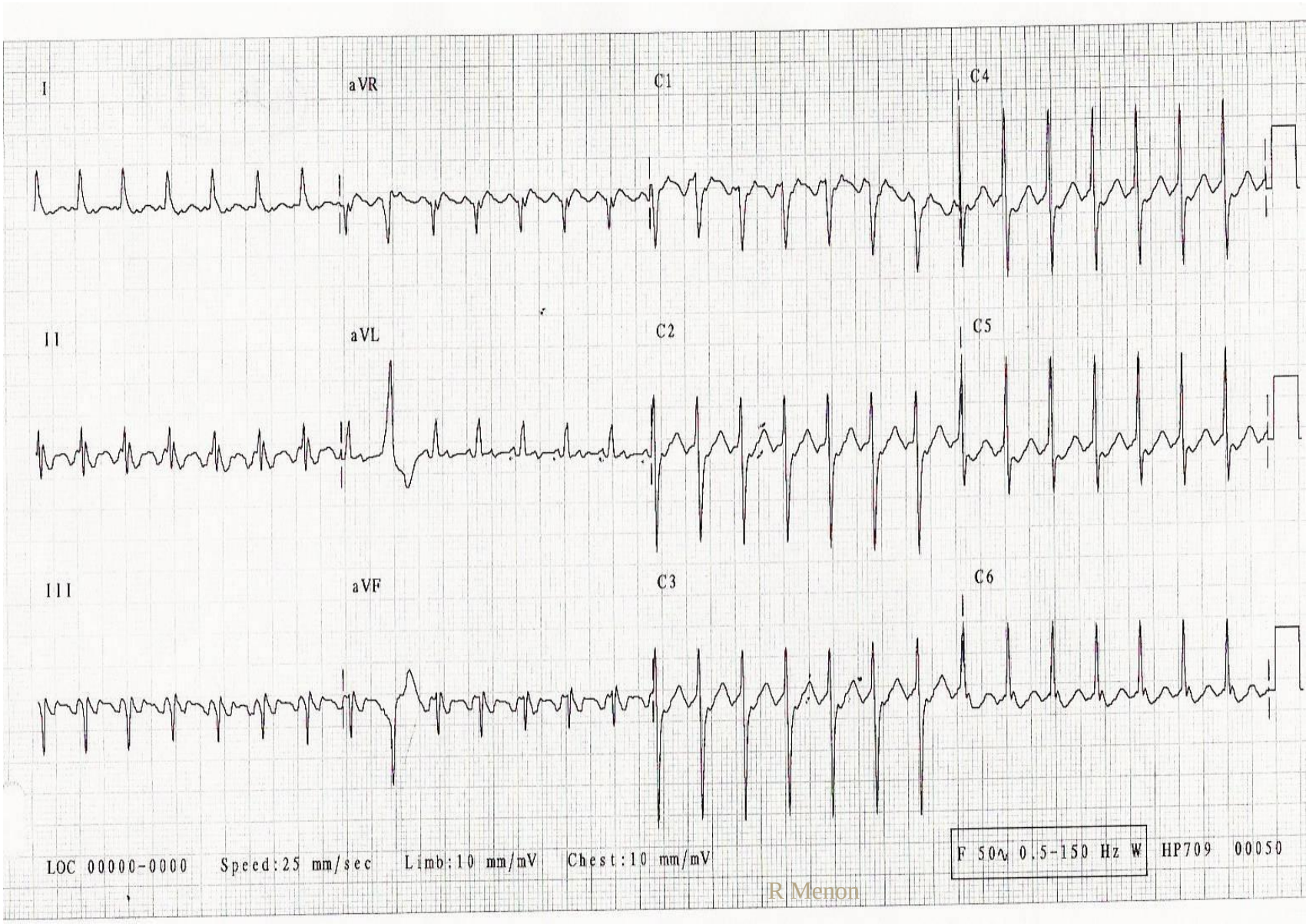
Escape Rhythms

- Junctional Escape Rhythm
- Idio-ventricular Rhythm
- Accelerated idio-ventricular Rhythm (AIVR)

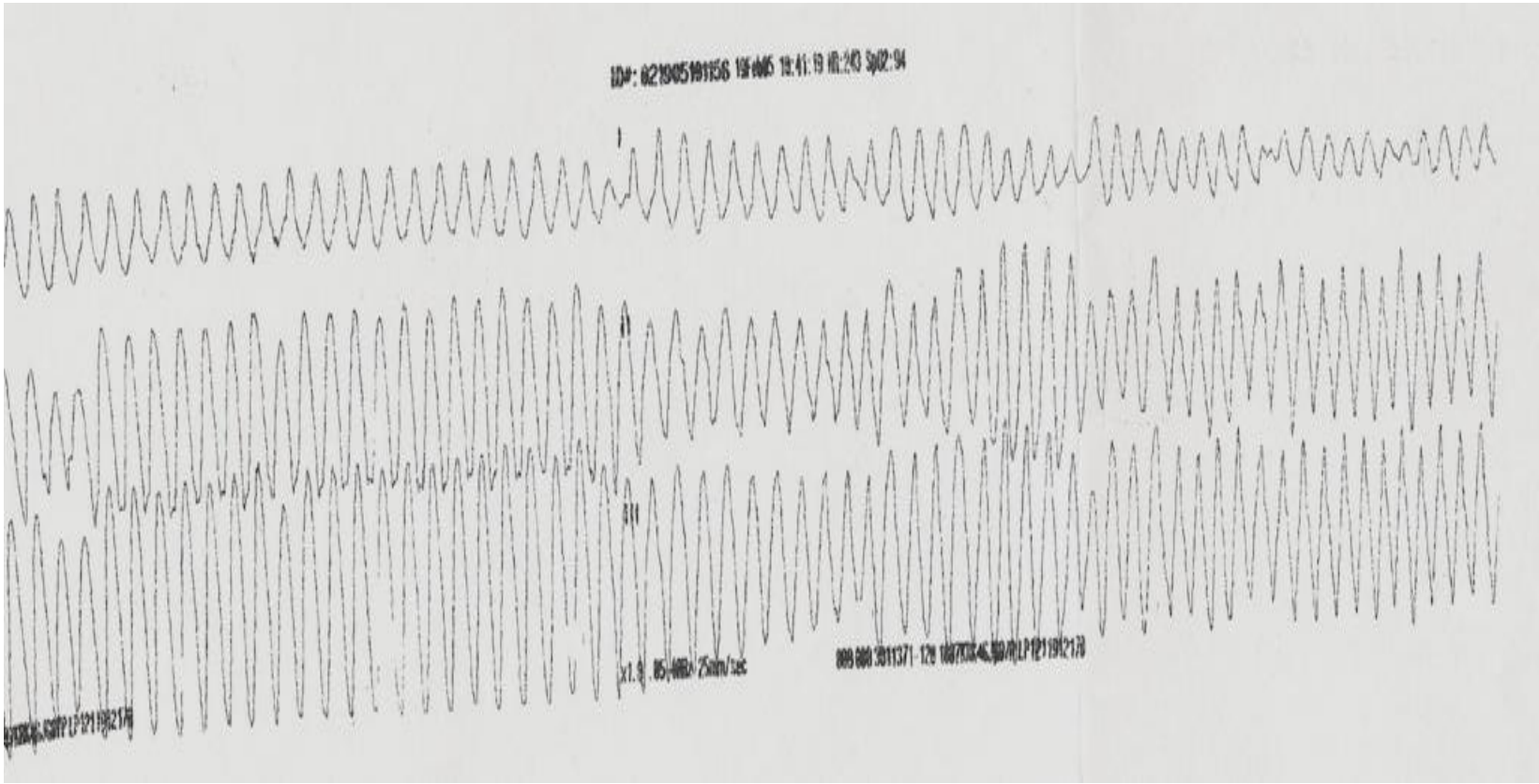
Tachy-arrythmias - Analysis

- Broad or narrow complex.
- Regular or irregular.
- P wave and P-QRS relationship.
- Atrial tachycardia, atrial flutter, AF and AVRT and AVNRT.
- Ventricular tachycardia vs SVT with aberrancy and AF in WPW.
- VF and polymorphic VT/Torsades.

Atrial flutter

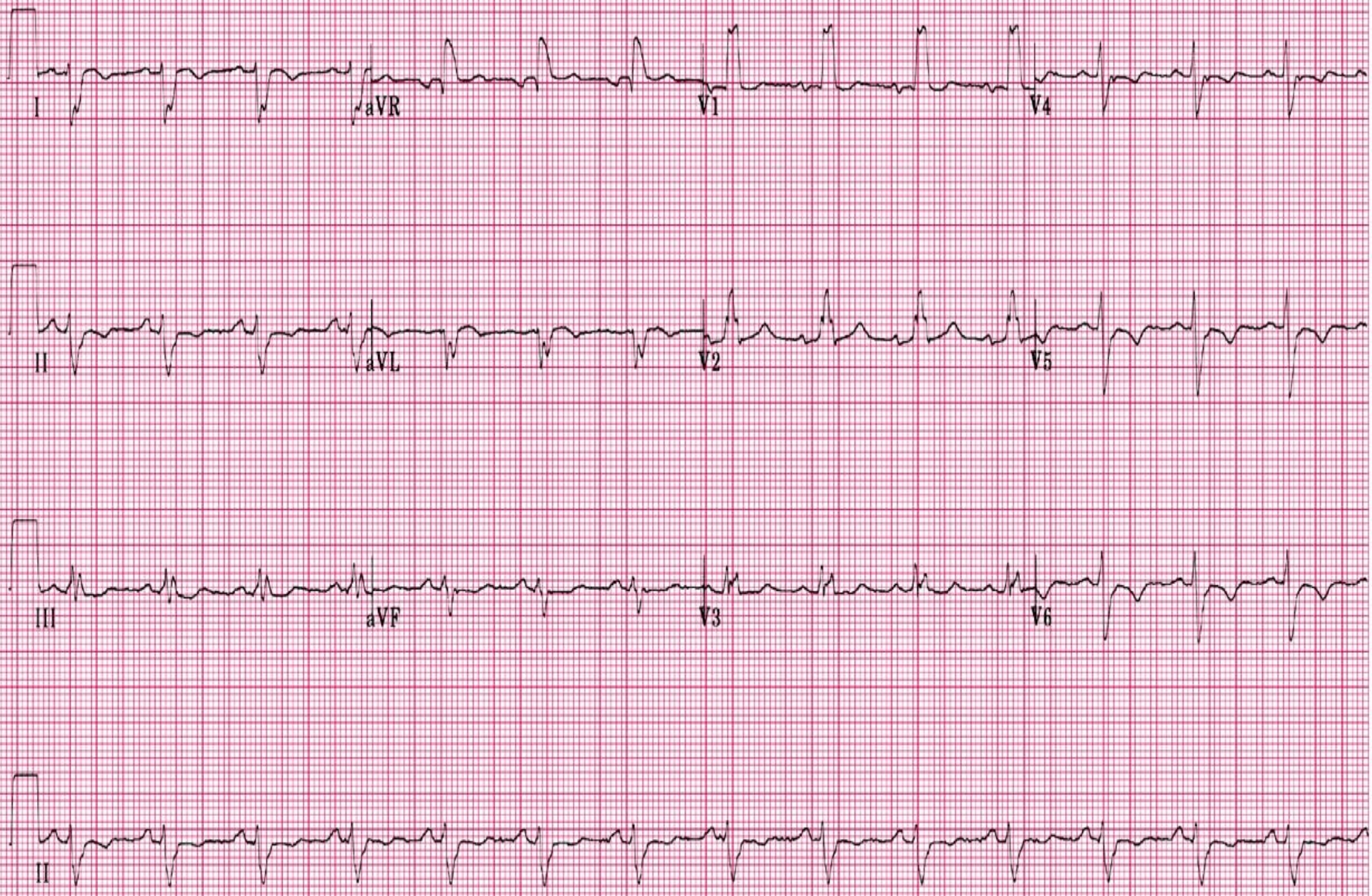


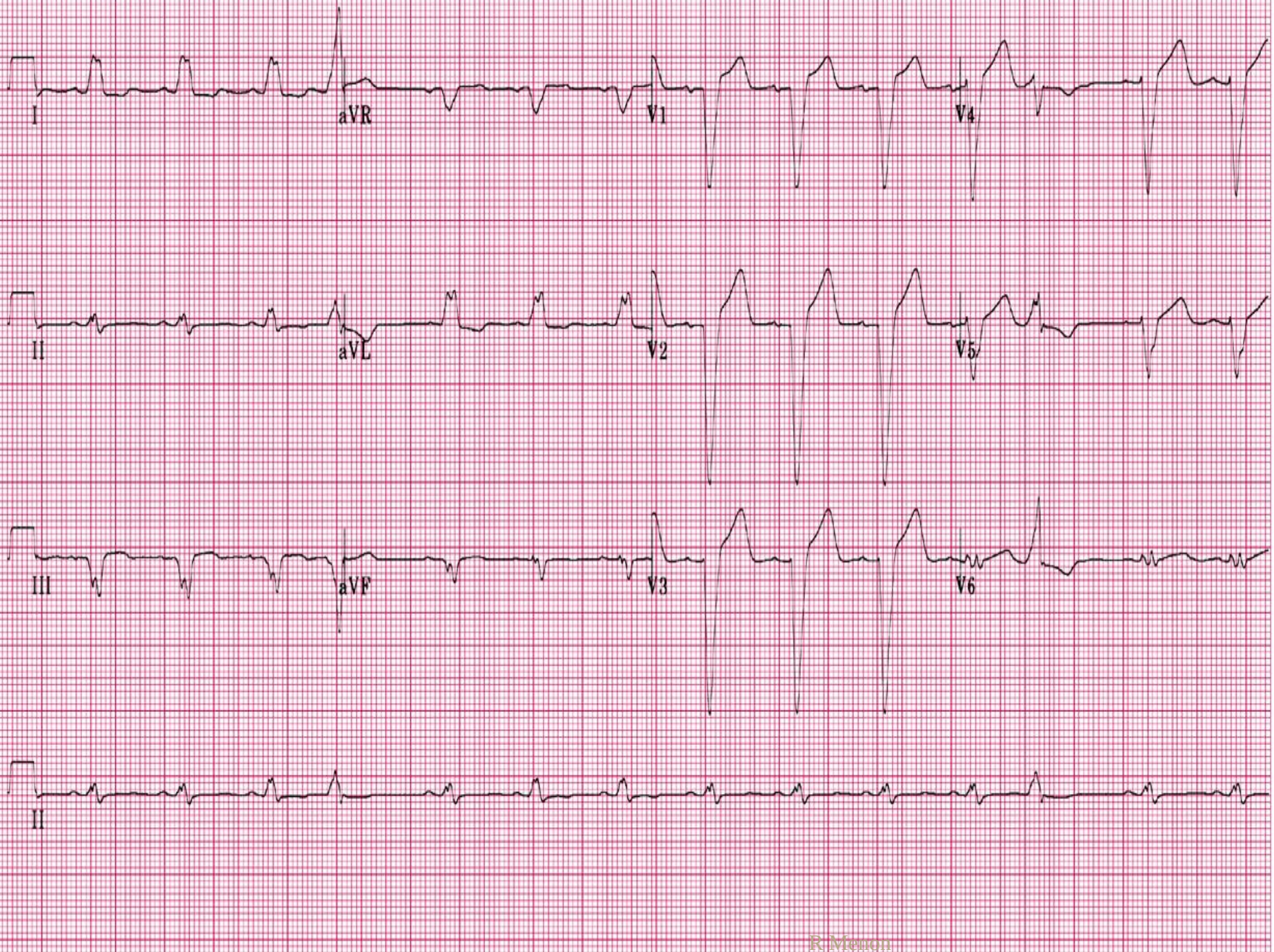
Beware of this!



Bundle branch blocks

- Complete BBB – QRS duration > 120 ms
- RBBB – RSR', or rsR', rSR' or W pattern in V1 and prolongation of terminal QRS deflection in left sided leads –avL, V6 etc, axis normal –(remember hemi-blocks)
- LBBB – Lt. Leads show monophasic upward M pattern QRS, discordant ST seg.
- BBB – if *terminal* deflection of the QRS complex is positive, the T wave should be negative and vice versa
- Bifascicular, trifascicular and hemiblocks




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

Myocardial Ischaemia - Chronic

- 90% of cases resting ECG is normal.
- ST segment changes – especially ST segment depression – though usually in acute ischaemia rather than chronic
- T wave changes – usually T wave inversion though can be biphasic T wave.
- May show evidence of previous MI such as Q waves and reduced r wave height.

Myocardial ischaemia - acute NSTEMI and unstable angina

- ST segment depression usually; rarely ST elevation as in Prinzmetal's angina.
- T wave – flat, inverted or biphasic- not very specific.
- U wave inversion – rare but said to be specific.
- Development of Q waves in the absence of ST elevation can occur. Loss of R wave height can also be seen.

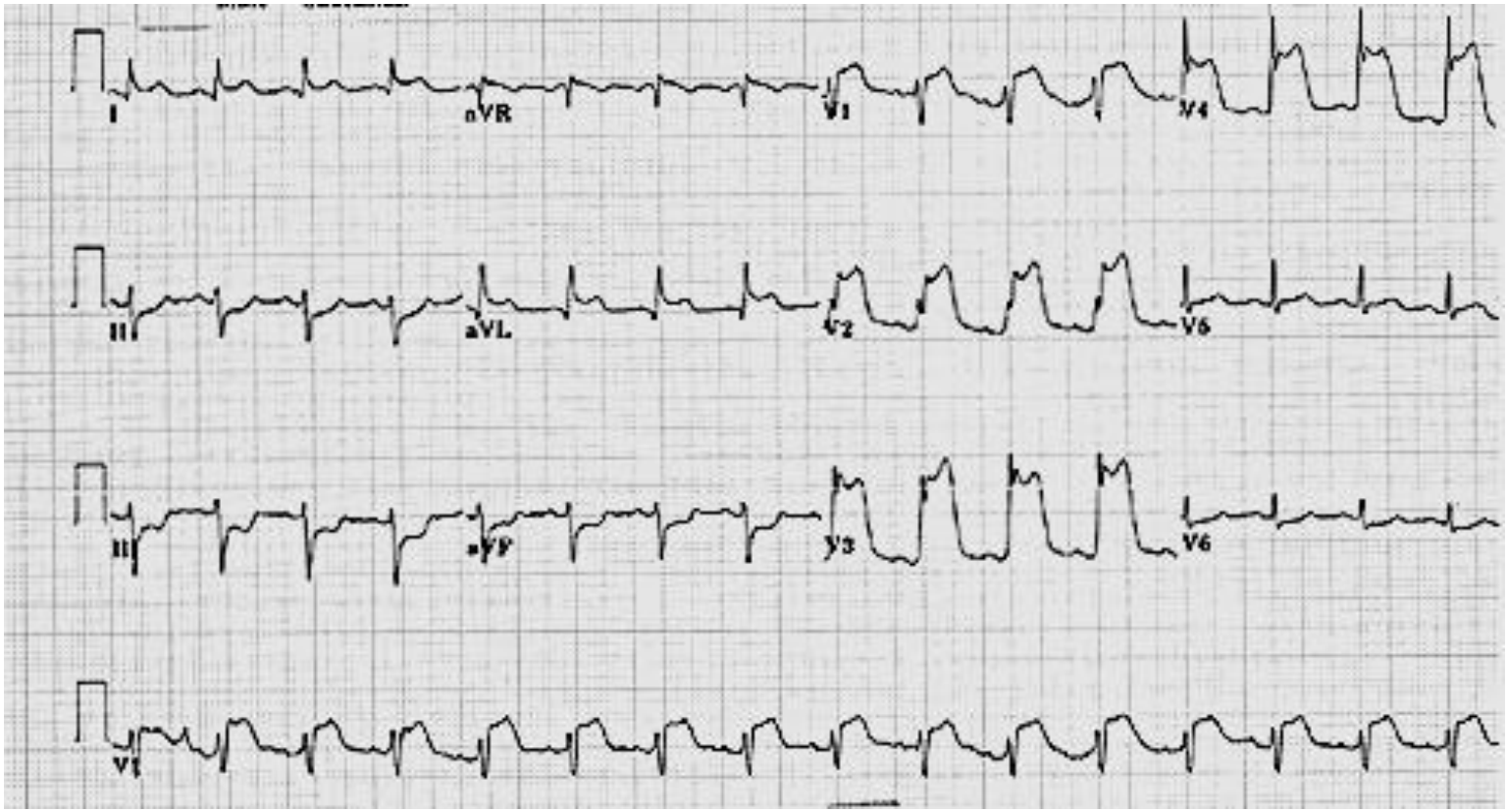
ST elevation Myocardial Infarction

- First change is usually peaking of T wave – so called tall peaked T waves or hyperacute T waves
- ST segment elevation in at least 2 consecutive leads. To thrombolyse/PCI follow the criteria.
- Convex upward ST segment elevation.
- Later ST elevation comes down and T wave starts to invert.
- Then there is loss of R wave height and development of Q waves (*significant Q – more than 30 ms in width and 25% of R wave height*).
- Even later the T waves may become upright but Q waves usually persist.
- Persistent ST elevation in the absence of pain for weeks after MI may indicate the development of aneurysm.

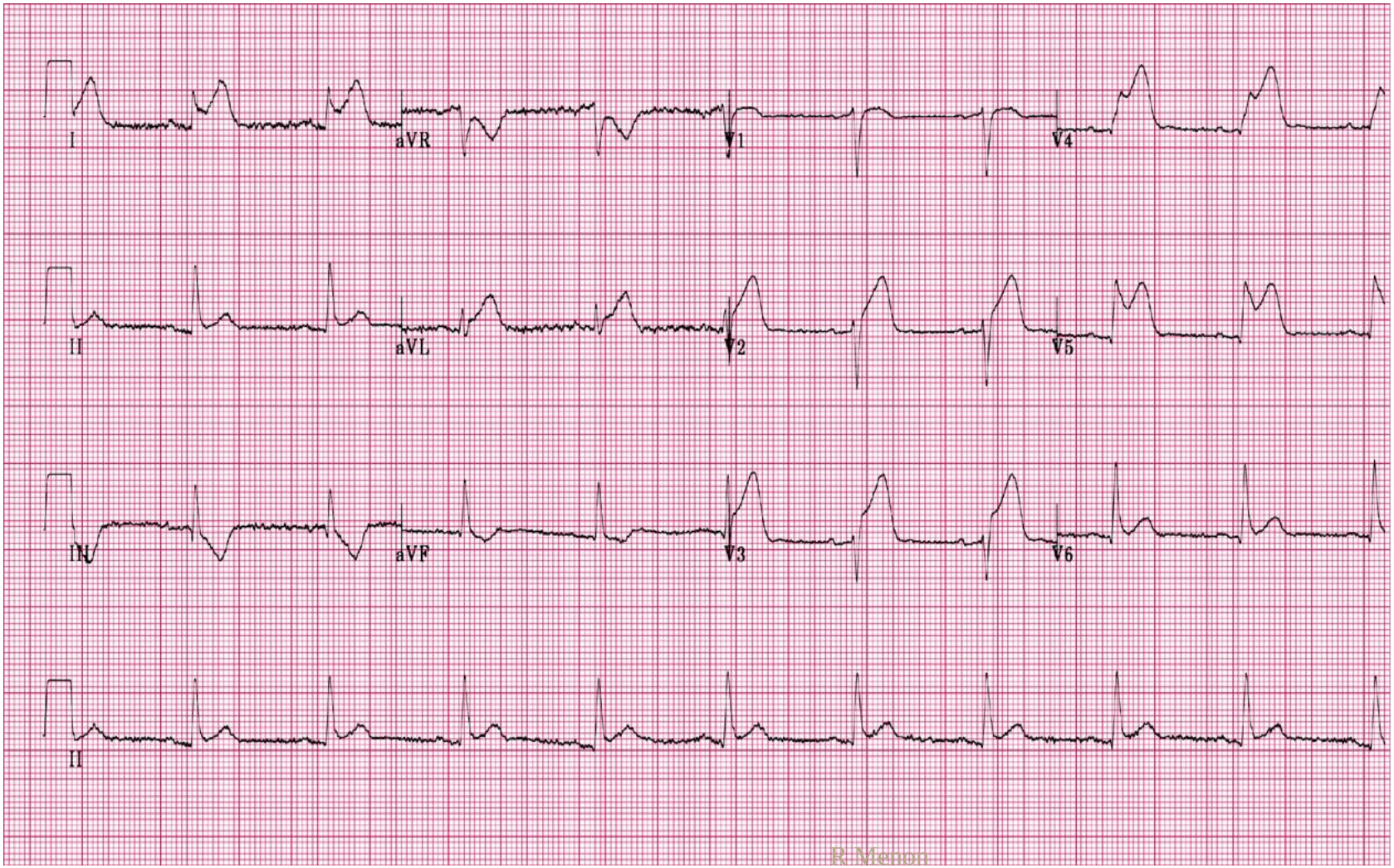
Unusual patterns in ischaemia

- Posterior MI – Usually associated with inferior MI. Presents with ST *depression* in V1, V2 along with *upright* T wave. Look for posterior leads – V7,8 and 9. Reverse ECG paper and look.
- New onset LBBB or RBBB.
- Right ventricular MI – Again along with inferior MI. If suspected – ask for right ventricular leads- RV1- RV6. Sometimes you can see ST elevation in V1 and V2.
- Clinically raised JVP with RVS3 and clear chest.

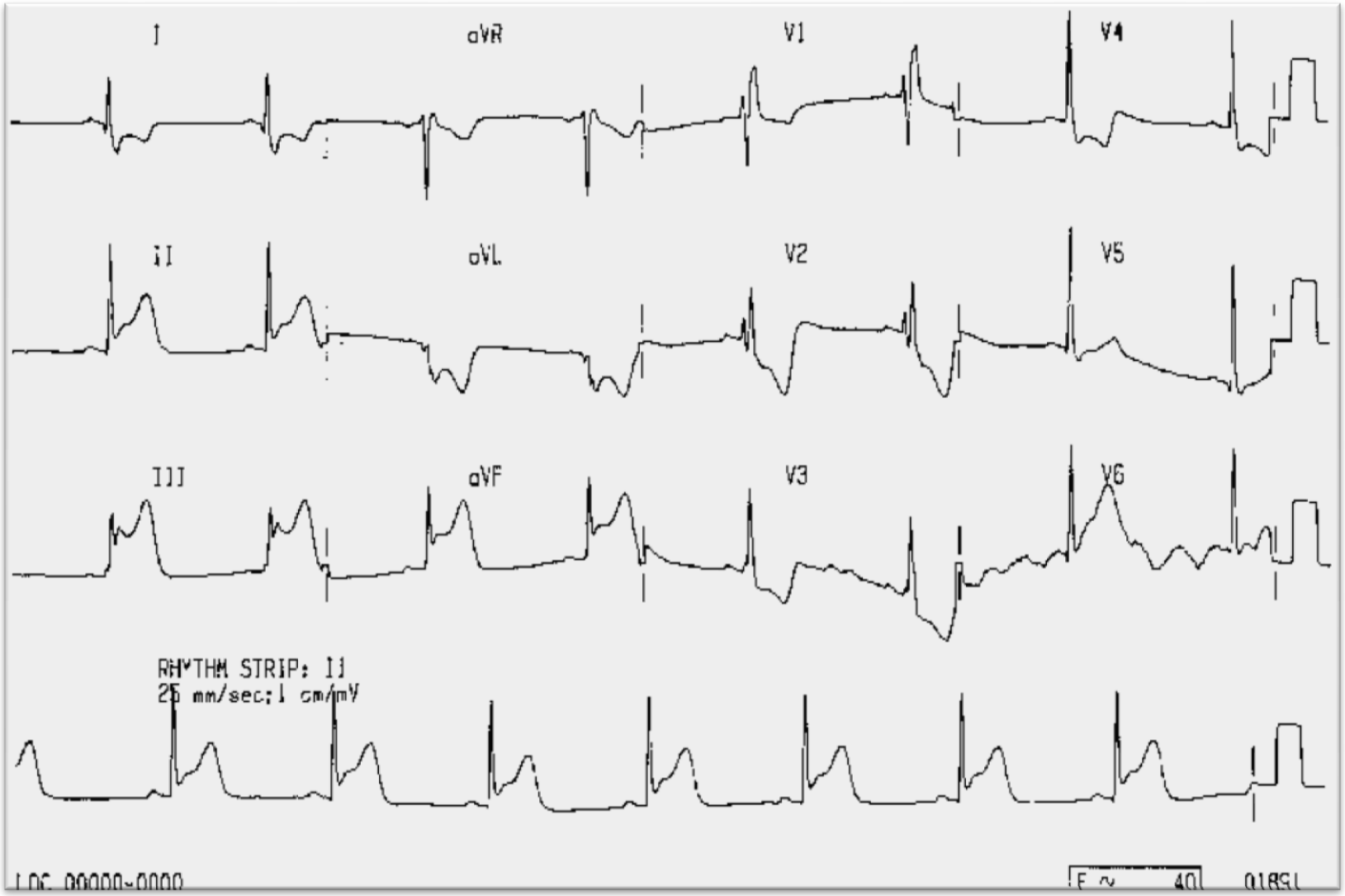
Acute Anterior MI



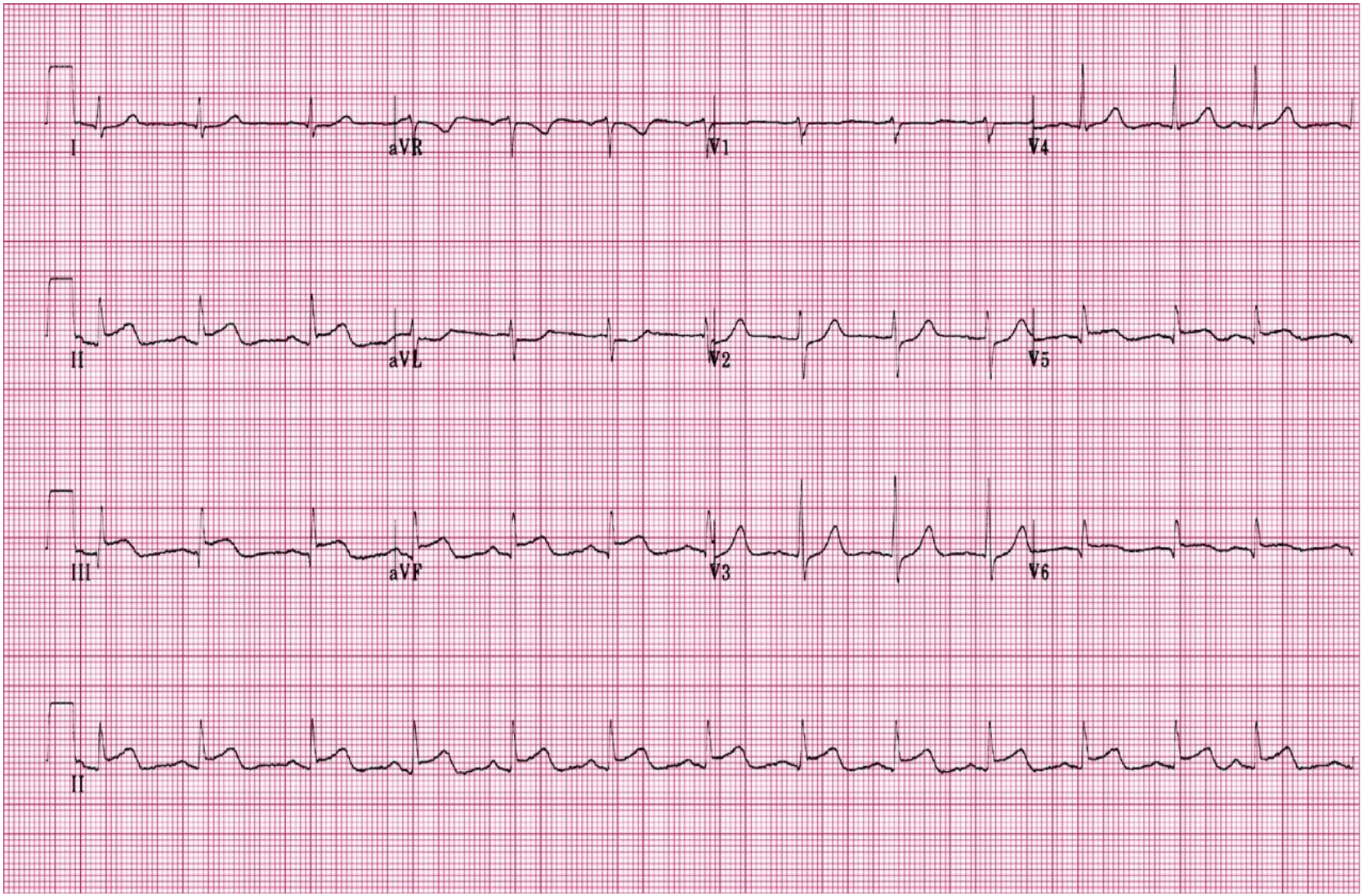
Antero-lateral STEMI



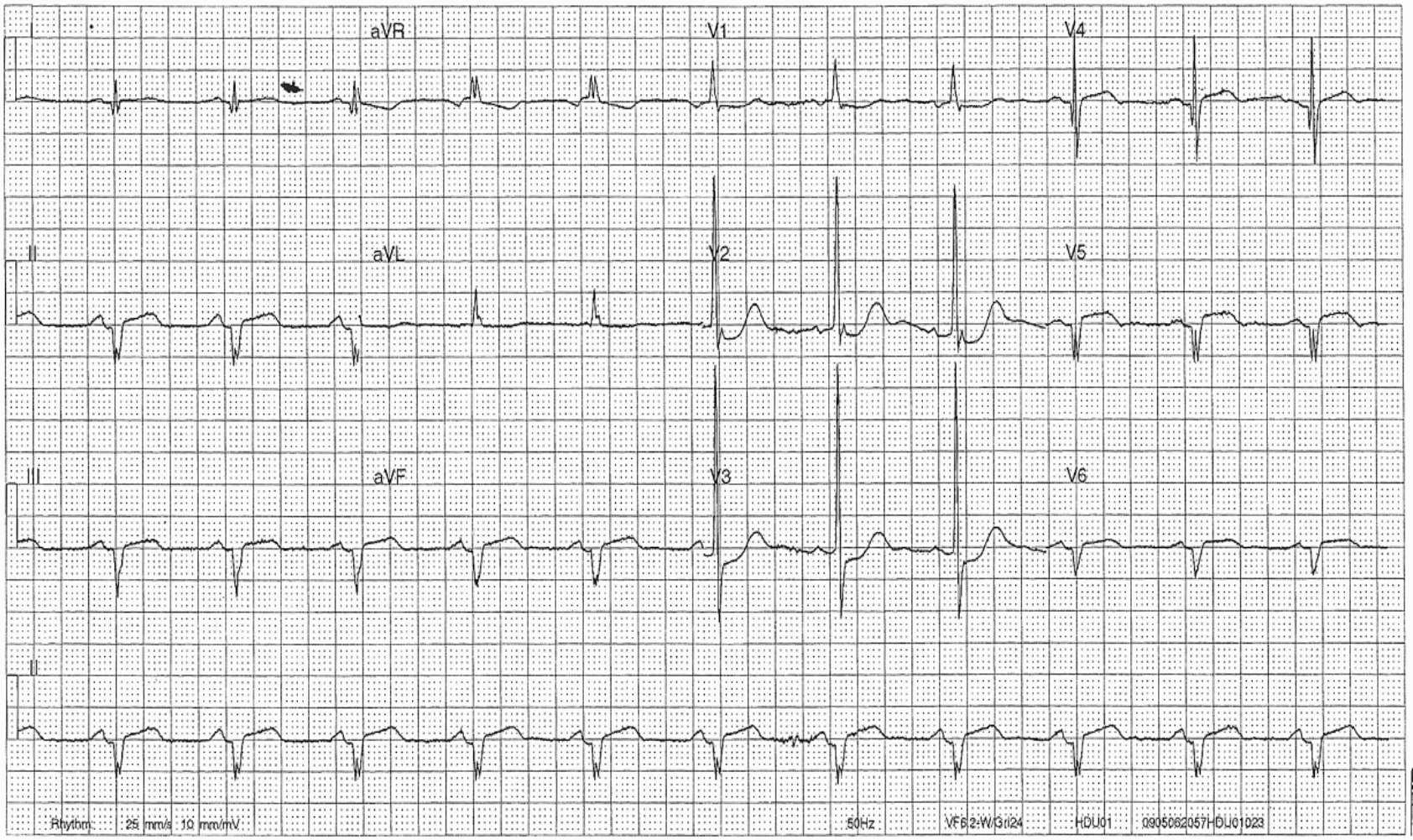
Acute Inferior MI



Acute Inferior STEMI



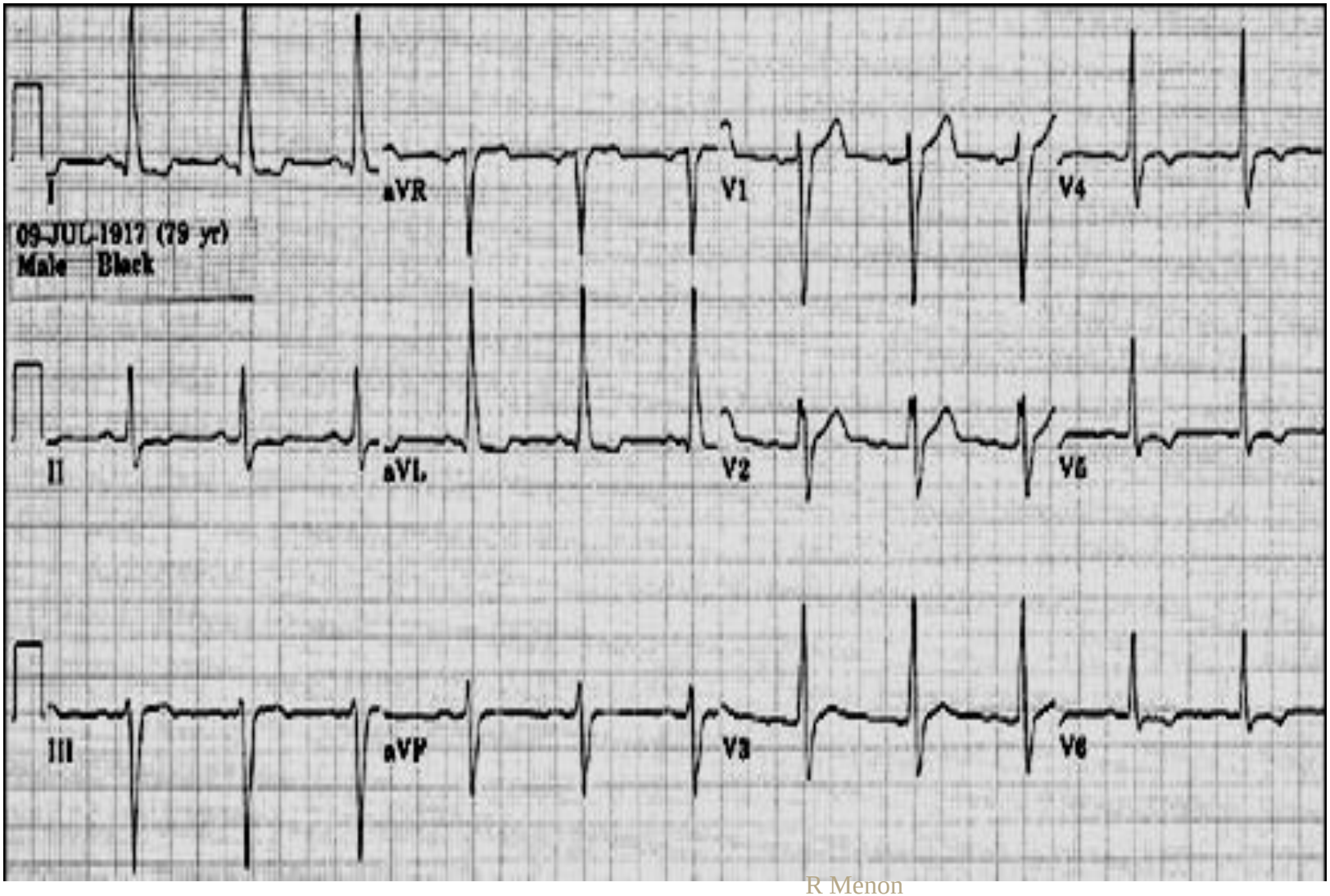
Posterior MI



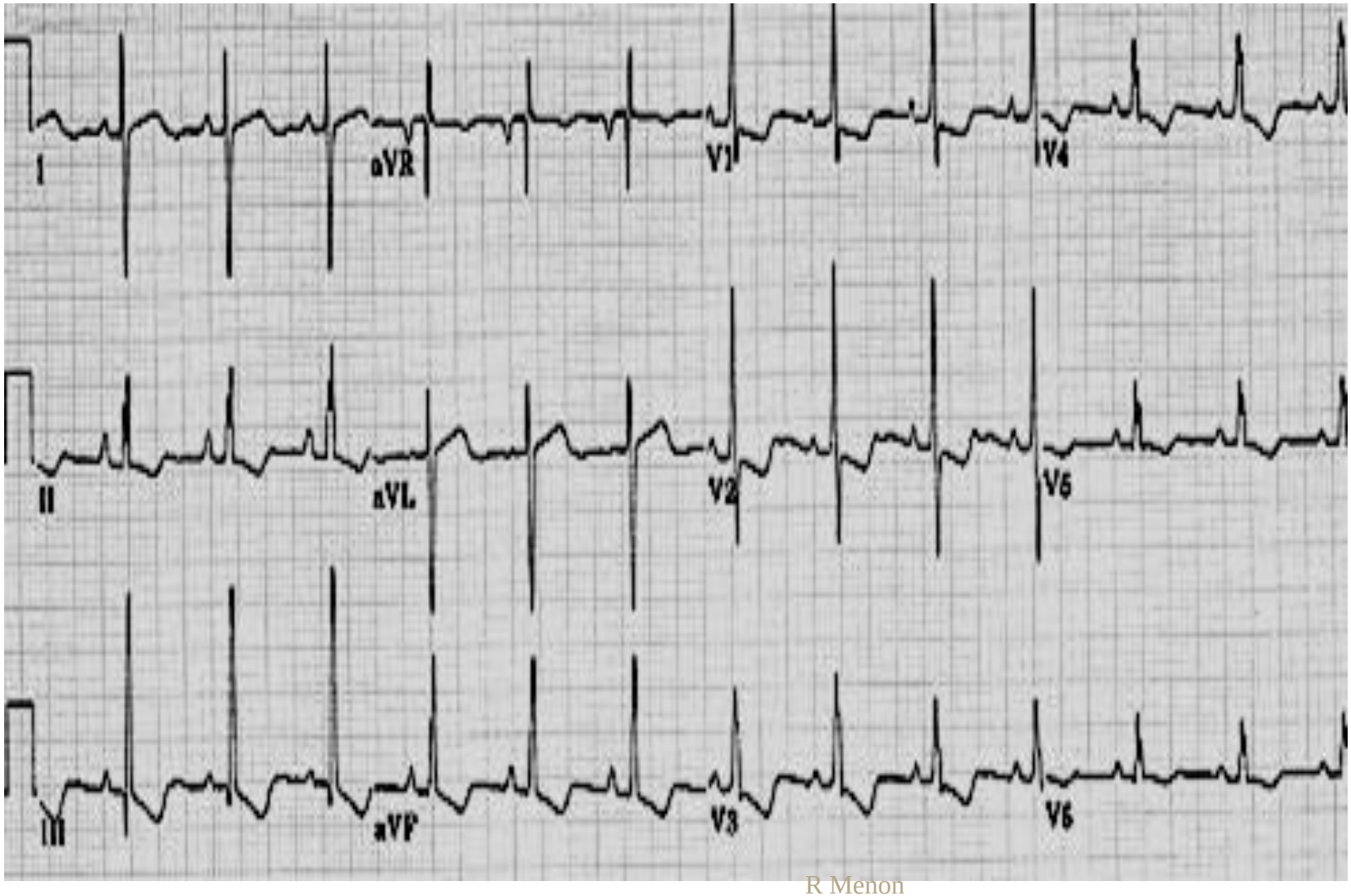
LVH and RVH

- RVH – R V1 + SV5/V6>11, R/S V1 > 1
- LVH – voltage criteria SV1+ RV5/V6>35
  RaVL>11, Cornell etc.
- Other criteria – LAE, ‘strain pattern’, intrinsicoid deflection, LAD etc
- Romhild-Estes criteria
- Atrial enlargement – LAE –P mitrale, P pulmonale, biatrial

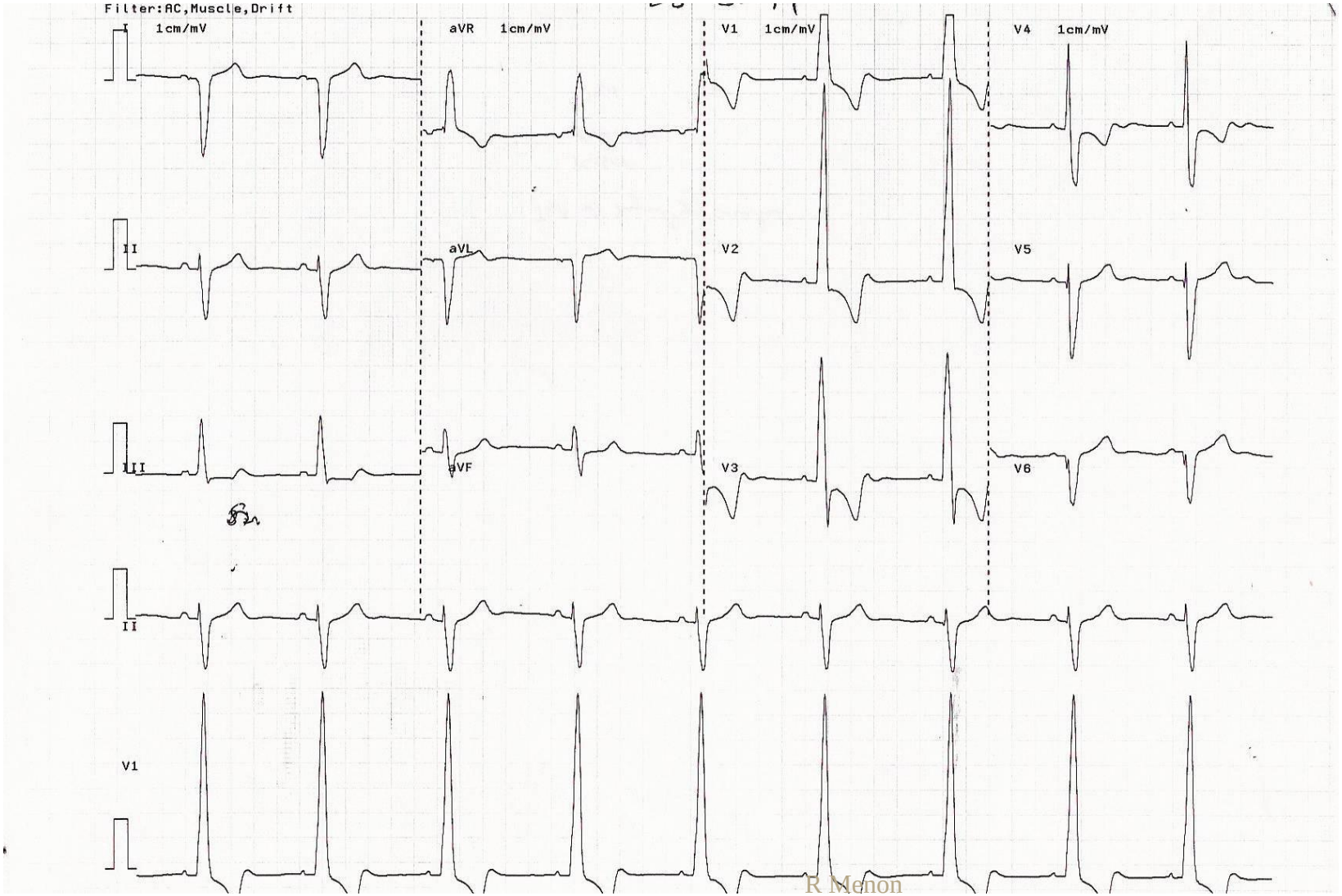
LVH with strain



RVH with strain



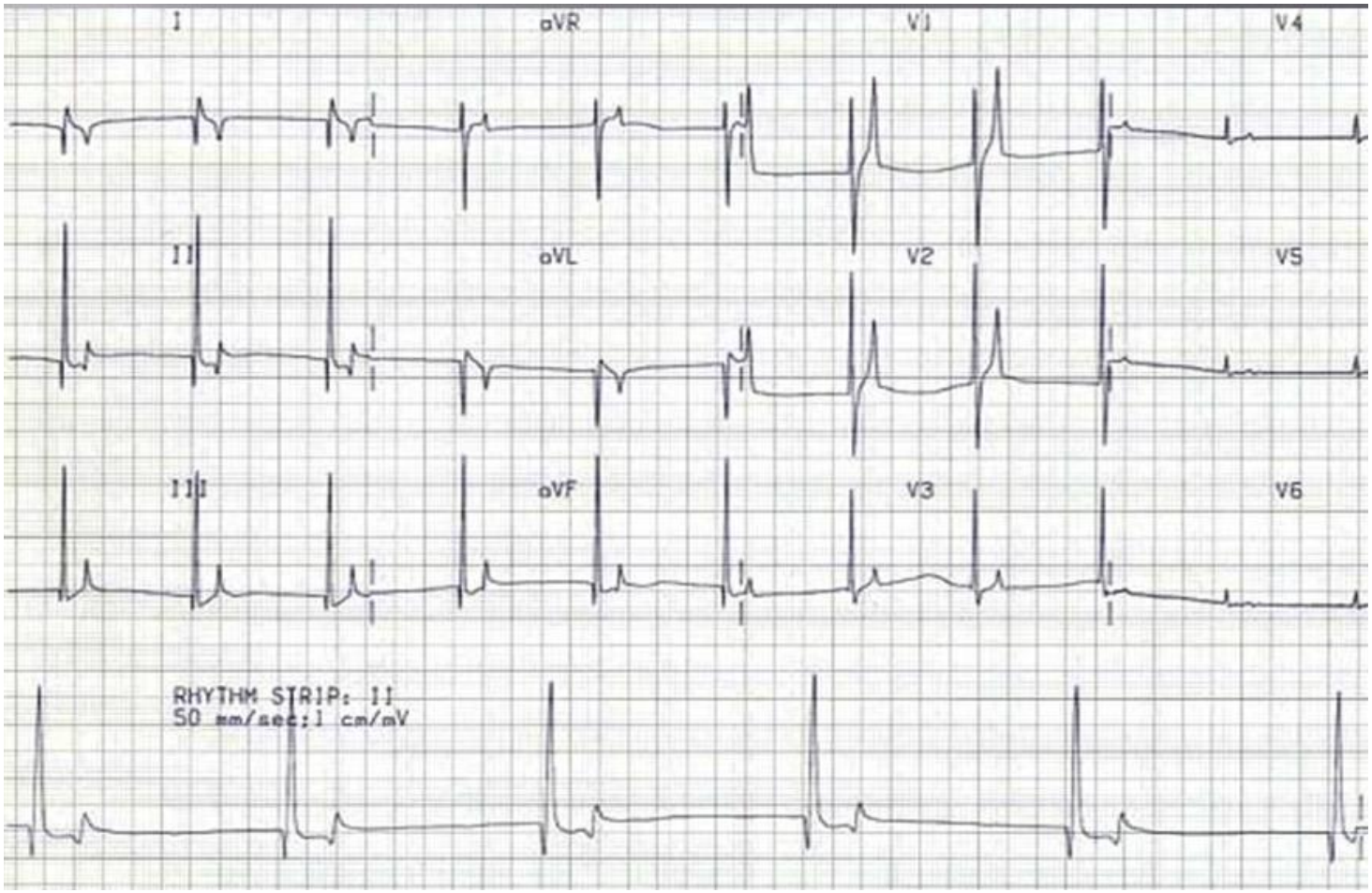
RVH with strain



Electrolyte abnormalities

- Hyperkalemia – T wave tall/peaked, flat P, PR lengthening, qrs widening, ‘sine wave’ and asystole
- Hypokalemia – Flat/inv T, prominent U wave, QT prolongation, atrial paralysis and TdP.
- Hypocalcaemia – QT prolongation, esp ST segment prolongation
- Hypomagnesaemia – similar to hypocalcaemia

Hyperkalemia



Hypokalemia

Miscellaneous

Pericarditis – ST segment elevations in multiple leads are seen not conforming to any vessels. Usually concave upwards ST segment elevation. In all leads except aVR and occ.V1. T wave changes may be seen.

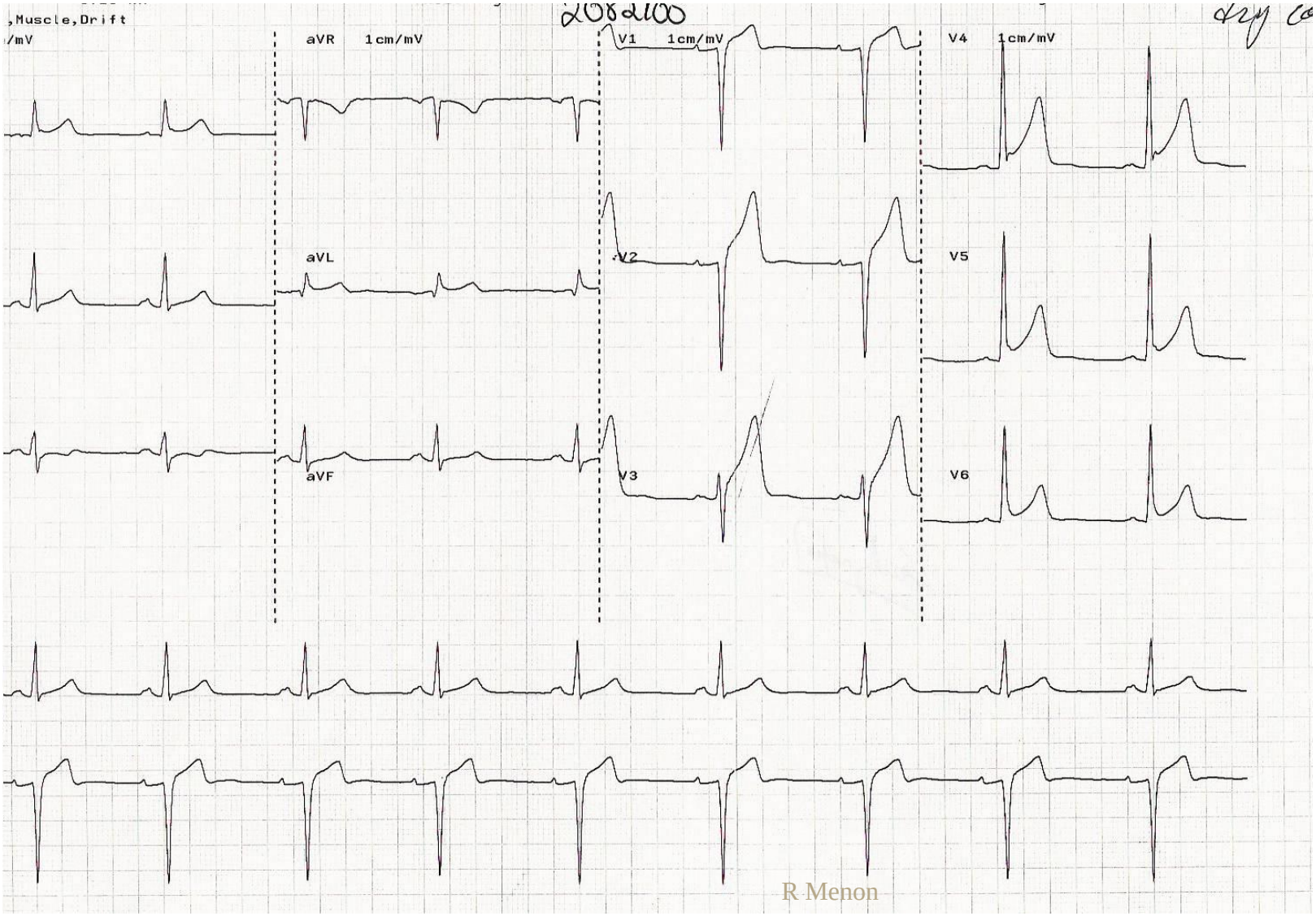
Myocarditis – T wave changes and arrhythmias are the usual pattern in acute setting. Later may have changes of dilated cardiomyopathy

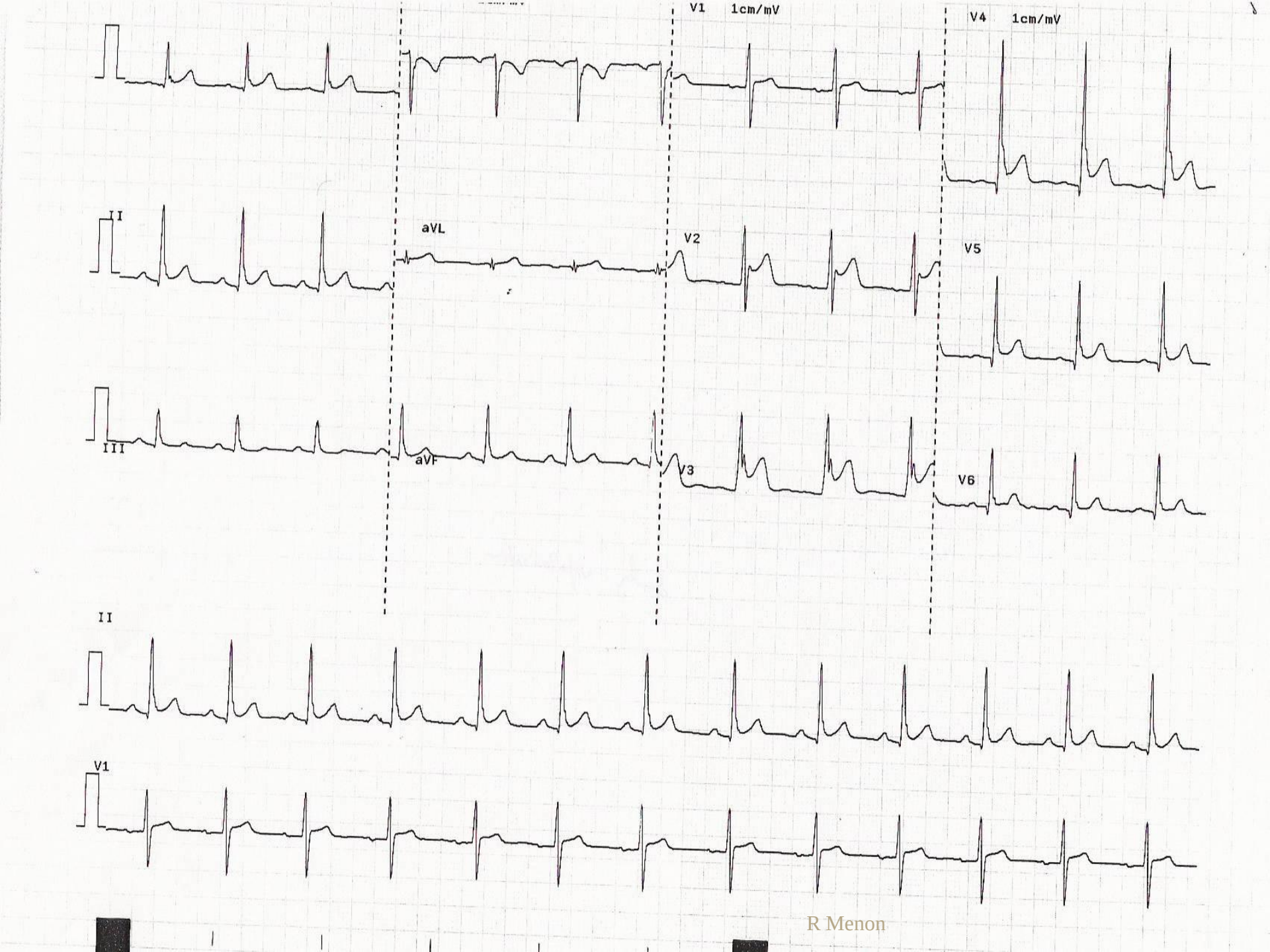
Normal Variants

Early repolarisation: ST elevation in usually lateral leads in young. May go away with exercise or occ. hyperventilation. Usually there is a J point deflection.

Persistent juvenile pattern: Persistence of the juvenile pattern of T wave inversion in anterior leads into adulthood, usually in women.

Early Repolarisation





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Rarities

Long QT syndromes such as Jervell and Lange-Neilsen and Romano-Ward - superseded by genetic classification now.

Brugada: ST elevation in V1/V2, partial RBBB pattern. J point deflection and coved upwards ST elevation are usual. F Hx or h/o tachyarrythmia necessary for diagnosis. Ajmaline test.

ARVC: VT with LBBB pattern. Epsilon wave - terminal notch in QRS complex in V1 usually - due to delayed IV conduction (signal av. ECG). T inv. In V-V3. Prolonged QT. RBBB - infrequent.

Thank You