UT Southwestern
Medical Center

Ecuador ECG Bootcamp

February 22nd, 2025

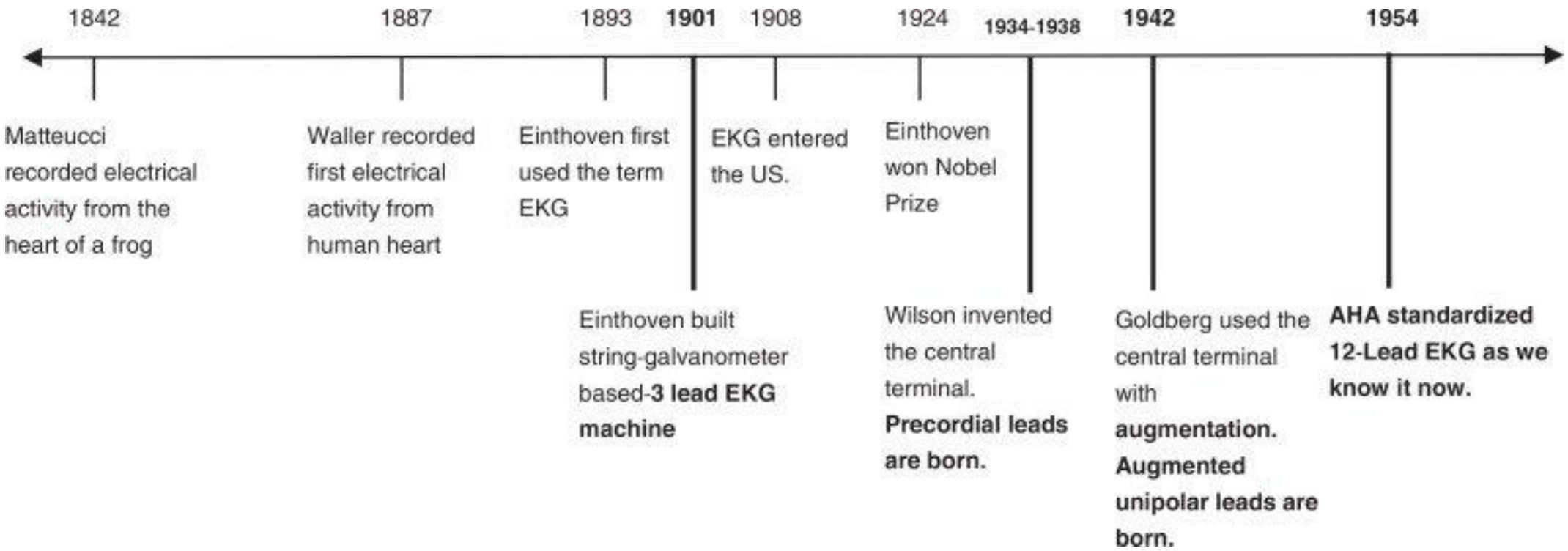
Guide for the day

- Please participate and ask questions.
- Please put your name and your year of training on your profile.
- Join the breakout session you are assigned to.
- Please fill out the survey at the end:

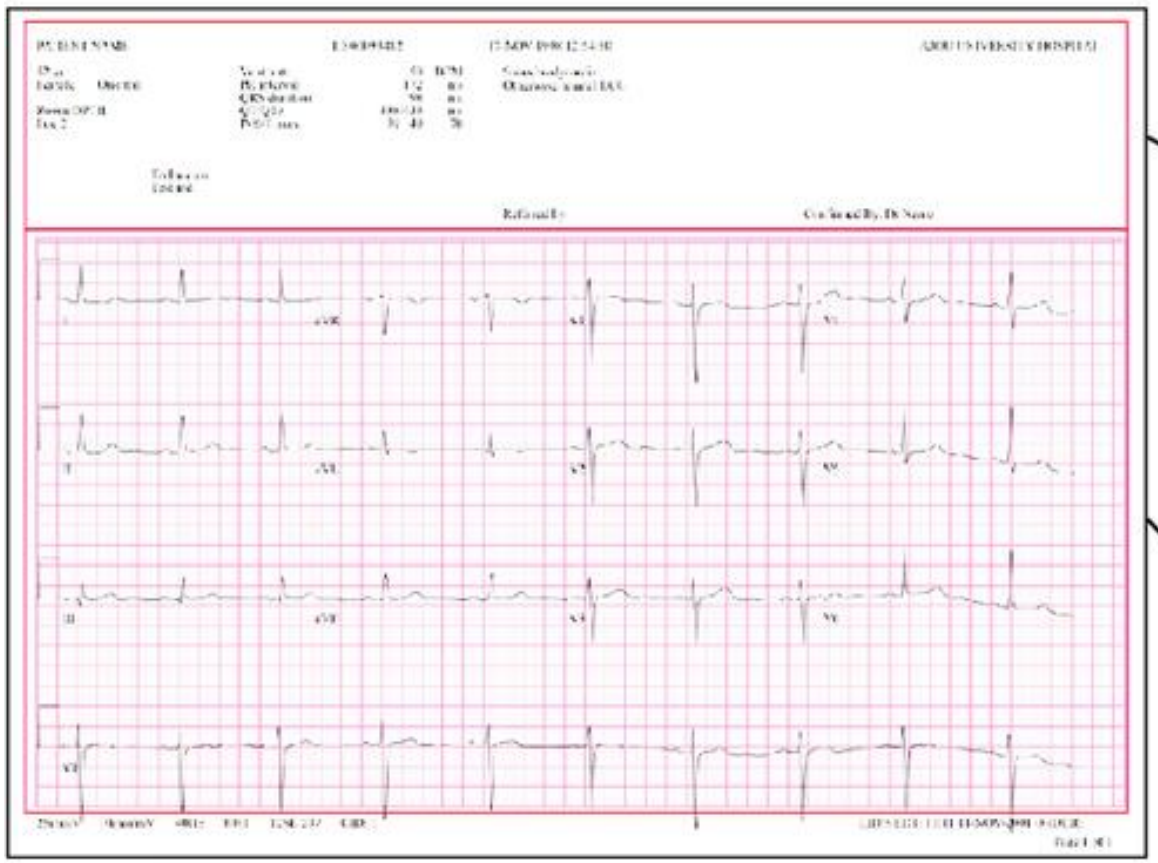
  https://www.surveymonkey.com/r/lHEEKG2

ECG BASICS

ECG vs EKG? Timeline



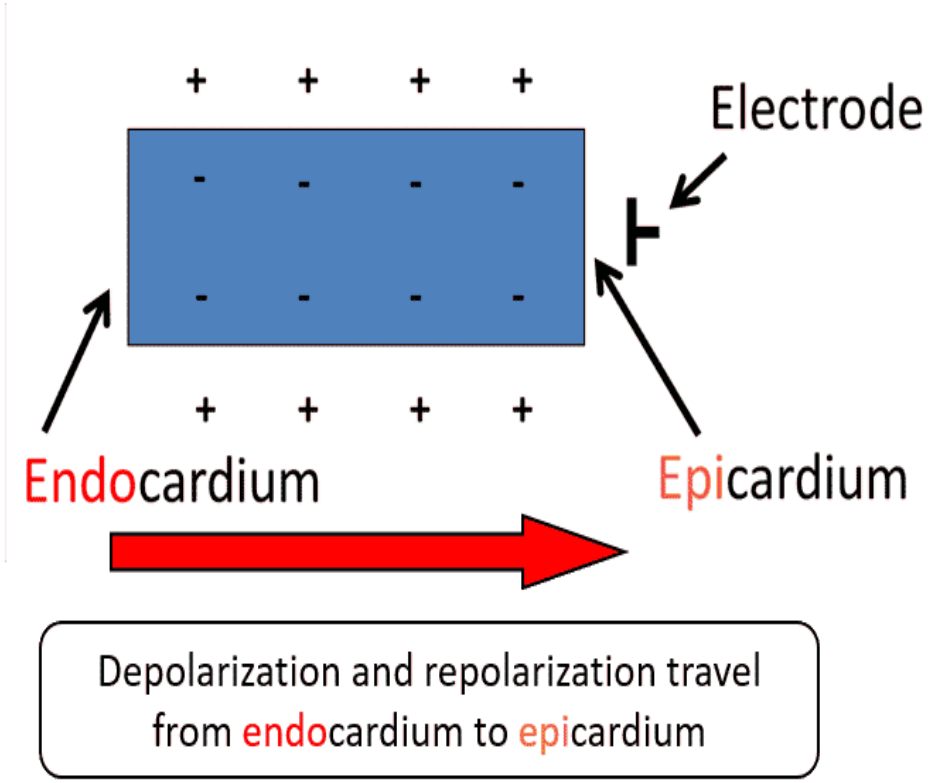
ECG: Elements

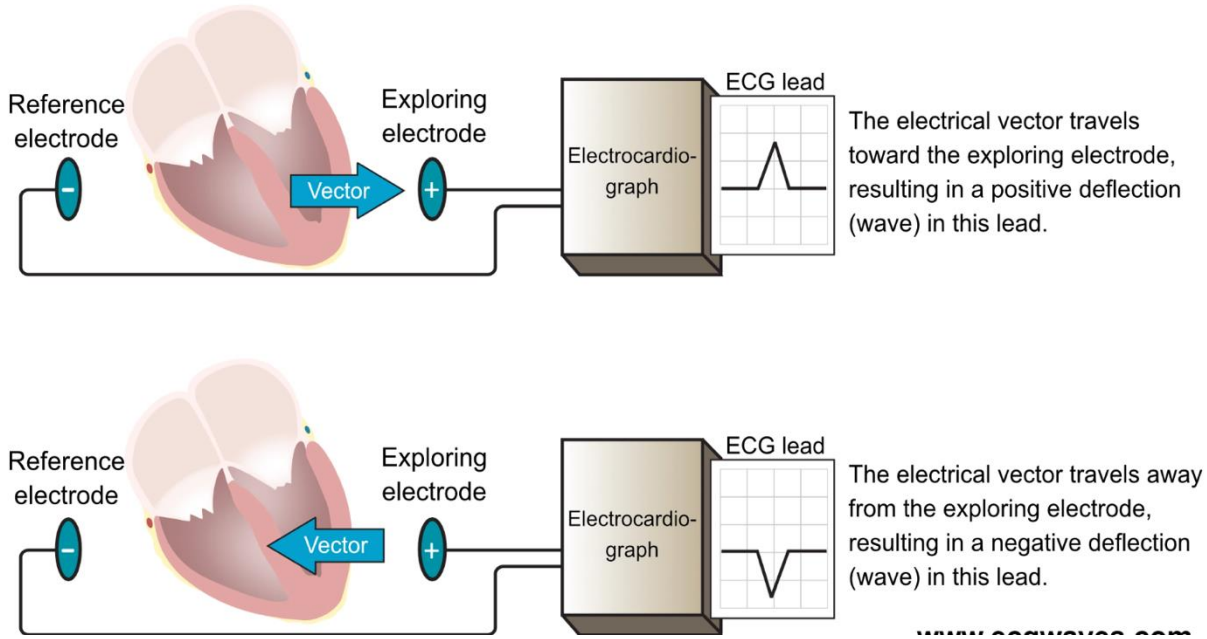


Alphanumeric value
- Demographic information
  - Patient ID
  - Date
  - Ethnicity
- ECG parameter values
  - Ventricular rate
  - PR interval
  - QRS duration
  - QT/QTc
  - P-R-T axes
- Interpretation

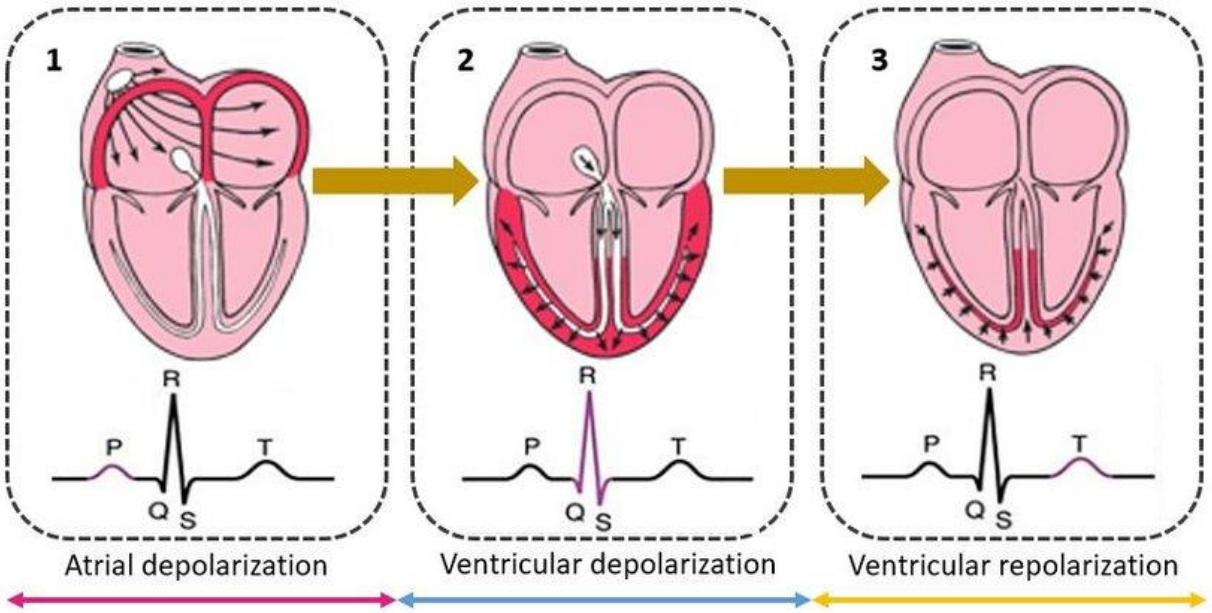
Waveform data
- 12 lead waveform data
  - I, II, III
  - aVR, aVL, aVF
  - V1, V2, V3, V4, V5, V6

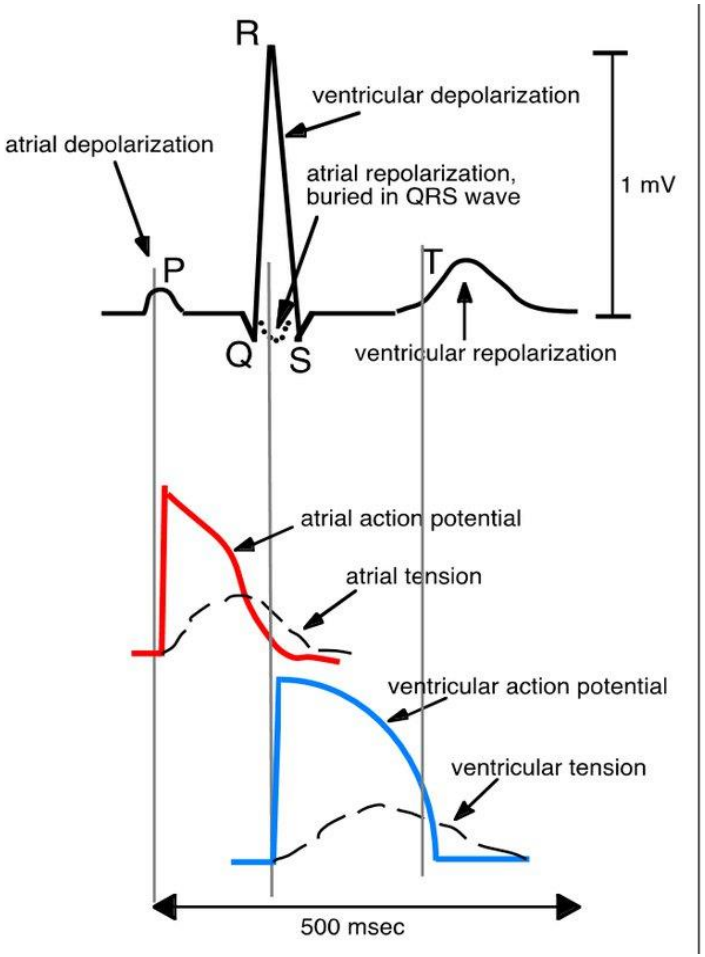
Depolarization & Repolarization



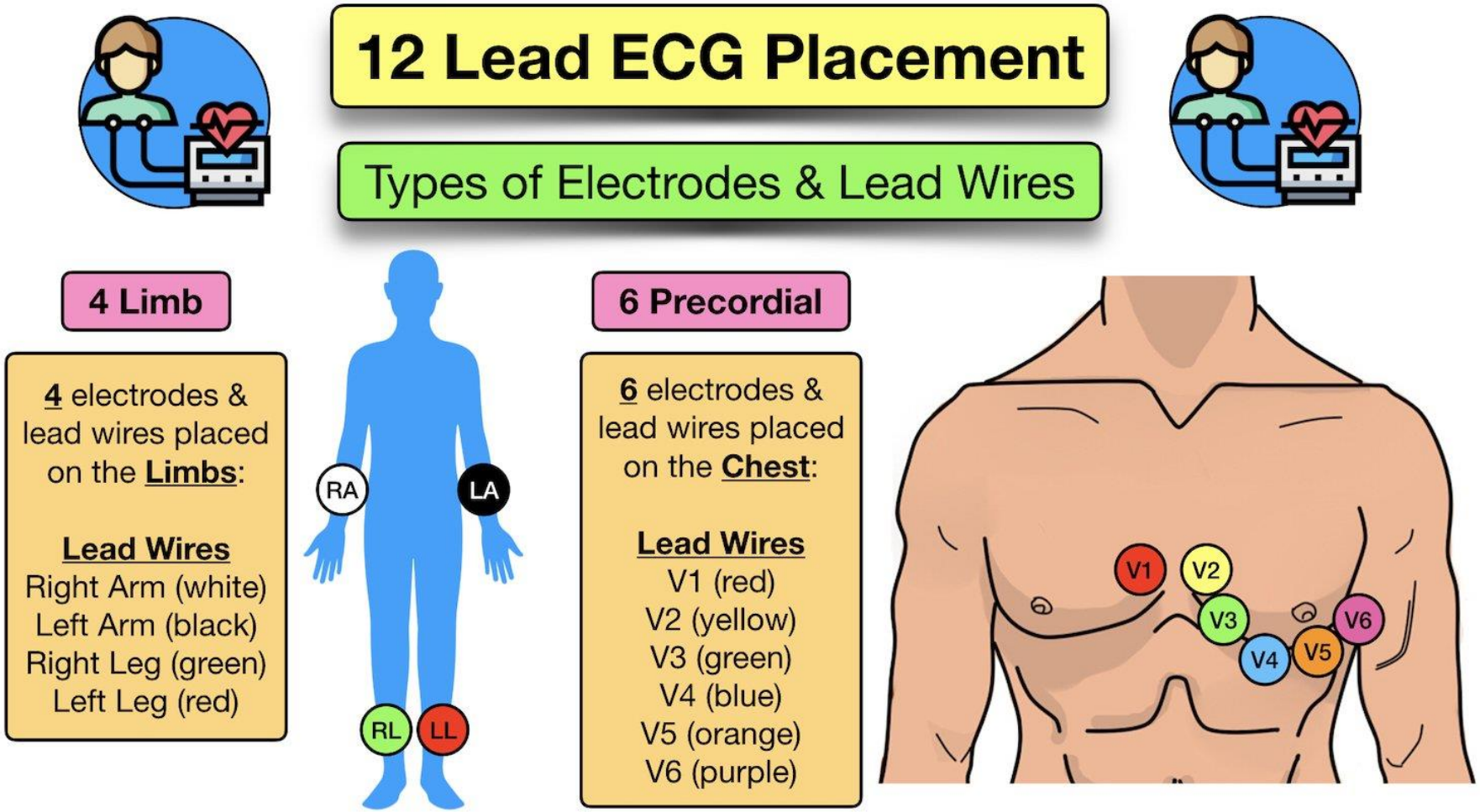


Depolarization & Repolarization





ECG Leads


12 Lead ECG Placement
Types of Electrodes & Lead Wires
4 Limb
4 electrodes & lead wires placed on the Limbs:
Lead Wires
Right Arm (white)
Left Arm (black)
Right Leg (green)
Left Leg (red)
RA
LA
RL
LL
6 Precordial
6 electrodes & lead wires placed on the Chest:
Lead Wires
V1 (red)
V2 (yellow)
V3 (green)
V4 (blue)
V5 (orange)
V6 (purple)
V1
V2
V3
V4
V5
V6

Sequence of Depolarization

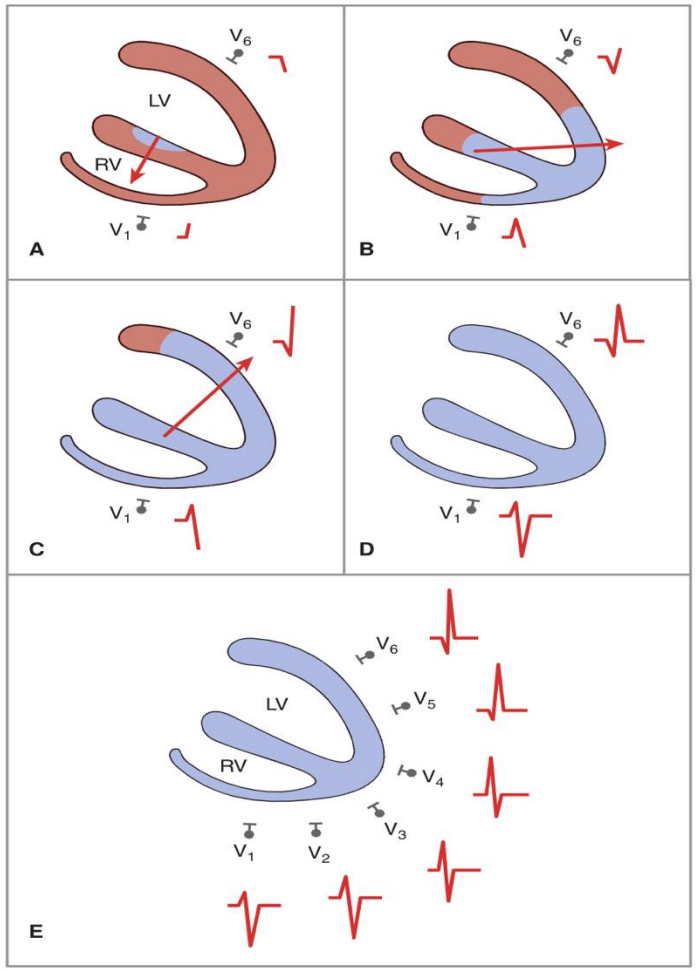
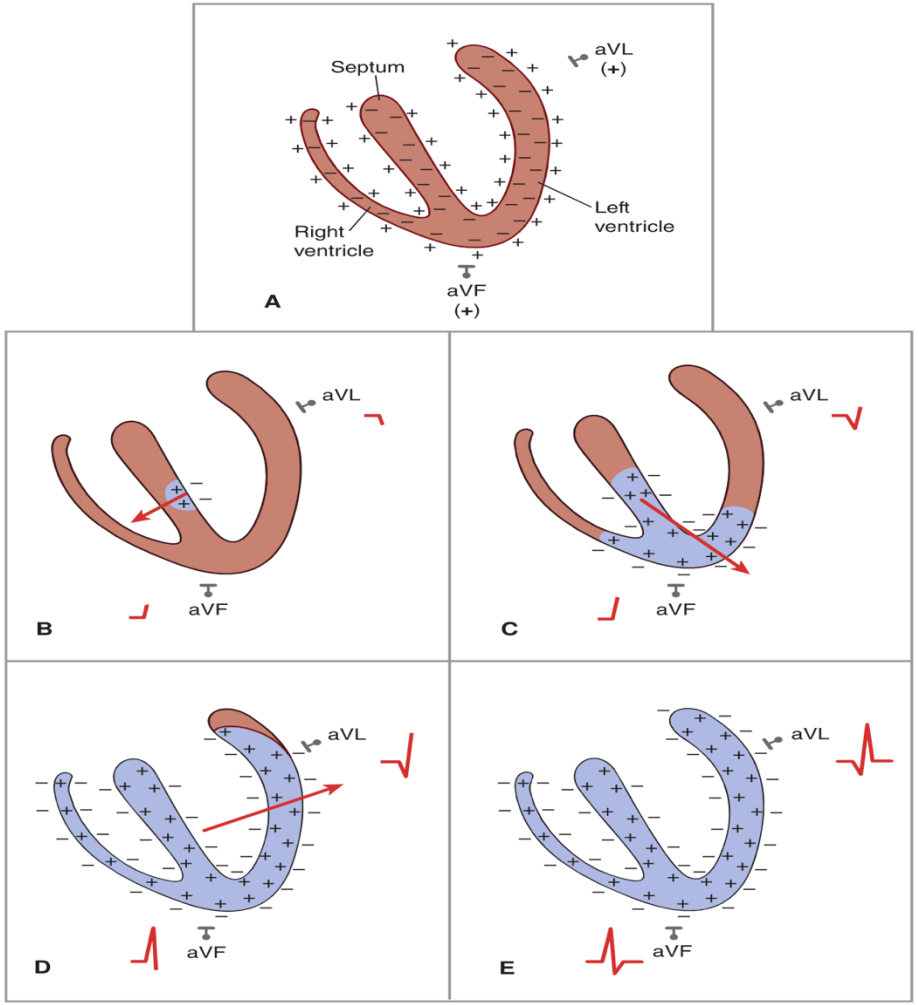
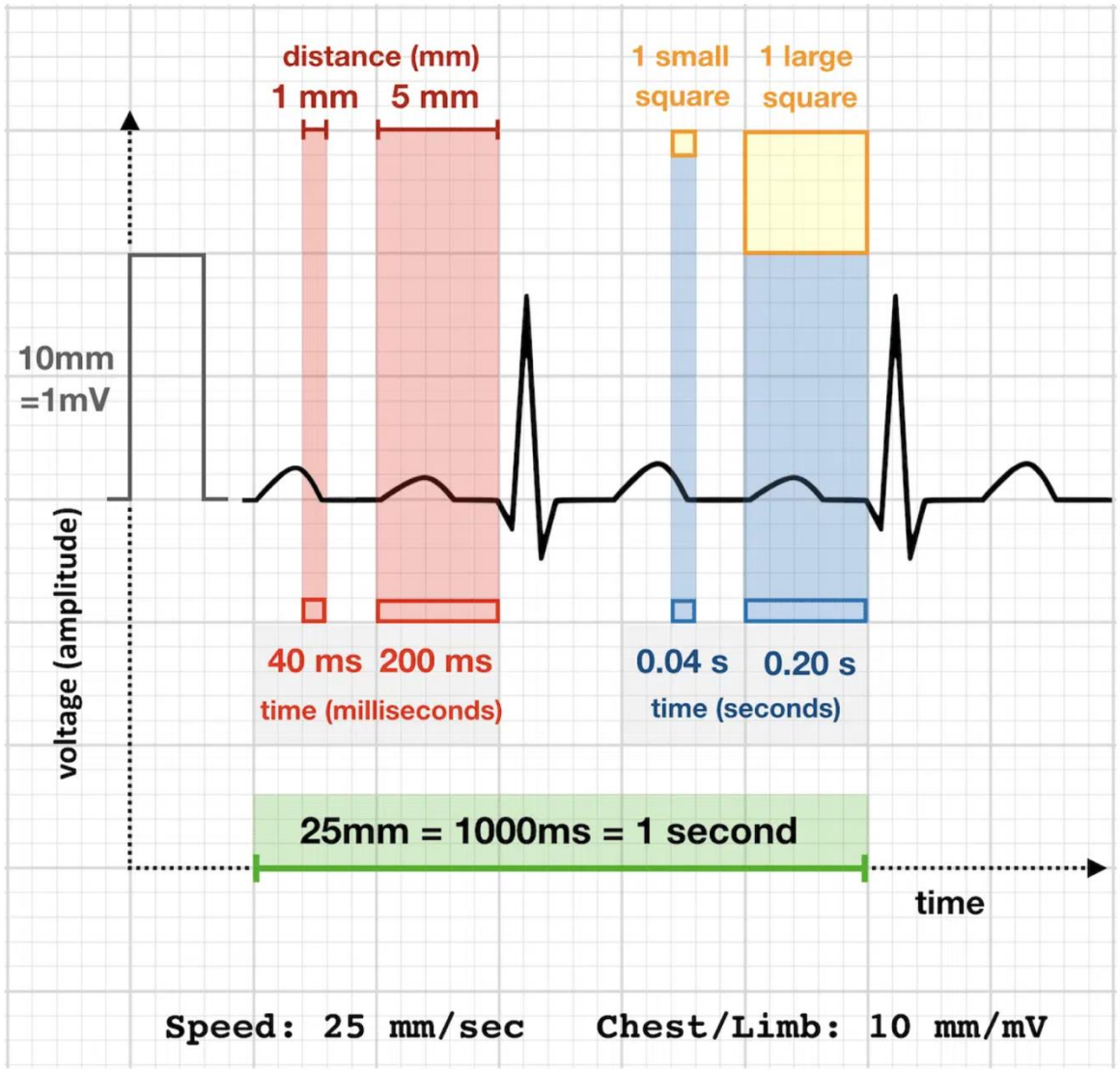


FIGURE 4-11. Sequence of depolarization in the transverse (horizontal) plane recorded by the chest (precordial) leads. A–D. Depolarization begins at the left side of the septum. The electrical vector then progresses posteriorly toward the thick-walled left ventricle. Thus, V_1, which is an anterior lead, records an initial upward deflection followed by a downward wave, whereas V_6, a posterior lead, inscribes the opposite. **E.** In the normal pattern of the QRS from V_1 to V_6, the R wave becomes progressively taller and the S wave less deep.

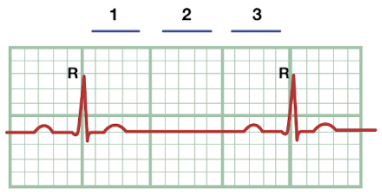


Standard Paper Measurements

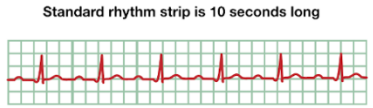


Rate Calculation

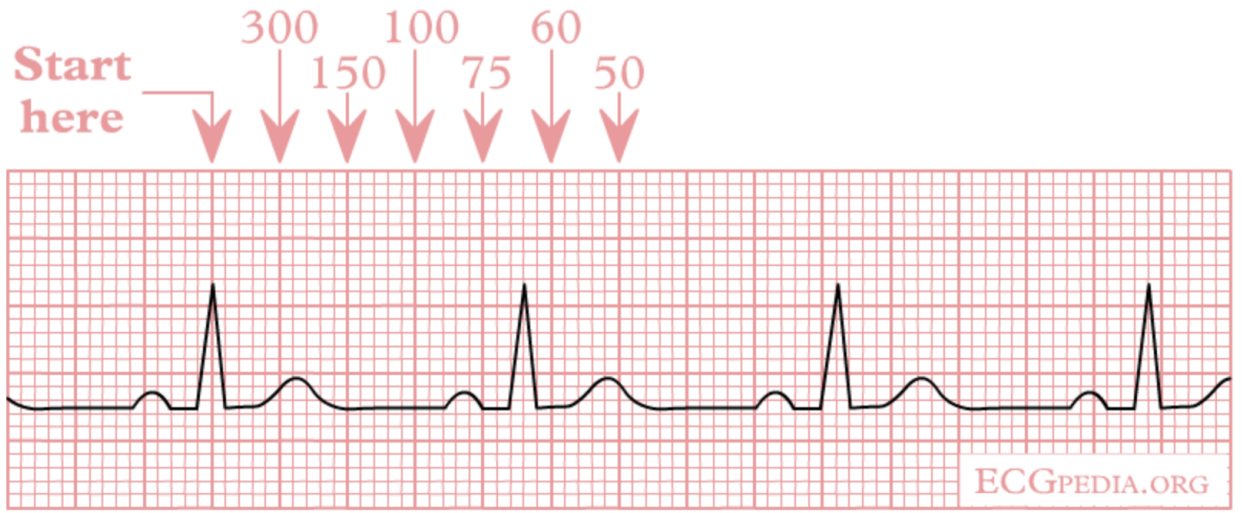
Large square method	R wave method
300 divided by no. of large squares between R-R interval	Number of R waves (rhythm strip) X 6



300/3 = 100 BPM



6 x 6 = 36 BPM



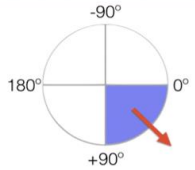
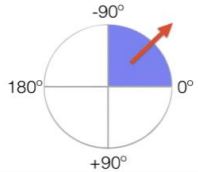
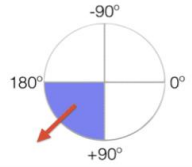
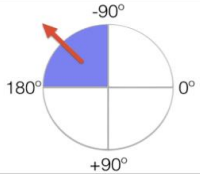
Rhythm

Regular Rhythm: R-R intervals are consistent.

Sinus Rhythm: Regular P waves present before each QRS.

- P waves are upright in most leads.
- Consistent P-R interval.
- Heart rate within 60-100 bpm, unless bradycardic or tachycardic.

Axis

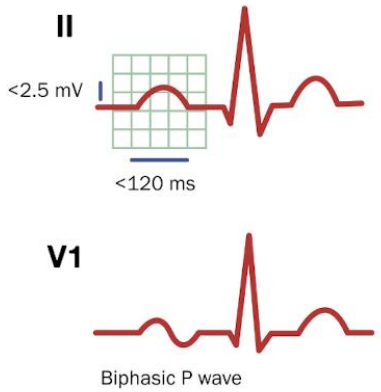
Lead 1	Lead aVF	Quadrant	Axis
POSITIVE	POSITIVE		**Normal Axis** (0 to +90°)
POSITIVE	NEGATIVE		****Possible LAD** (0 to -90°)
NEGATIVE	POSITIVE		**RAD** (+90° to 180°)
NEGATIVE	NEGATIVE		**Extreme Axis** (-90° to 180°)

Waves

P wave

Normal Morphology

1. Represents: Atrial depolarization
2. Normal duration: < 0.12 s (< 120 ms or 3 small squares)
3. Morphology: Positive in leads I and II (in sinus rhythm), Biphasic in V1
4. Amplitude: < 2.5 mm (0.25 mV or 2.5 small squares)

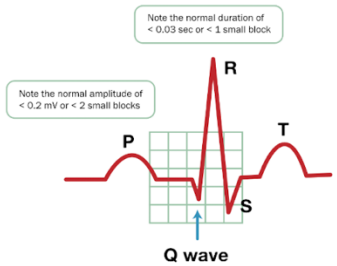


Waves

Q wave

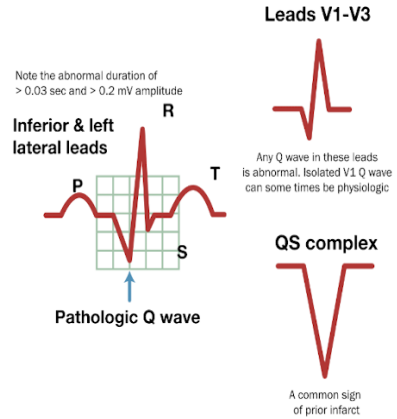
Normal Morphology

1. First negative deflection of the QRS complex before the R wave
2. If first defelction of QRS complex is positive then that will be R wave instead of Q wave
3. Represents left-to-right depolarisation of the interventricular septum
4. Duration: < 0.03 sec
5. Amplitude: < 0.2 mV (can be > 0.2 mV in lead III and aVR as a normal variant)
6. Small Q waves are seen in most leads except right-sided leads (V1-3)



Pathologic Q waves

1. Any Q wave in lead V2V3 >= 0.02 s or QS complex in leads V2 and V3
2. Q wave > 0.03 s or > 0.2 mV in amplitude or QS complex in leads I, II, aVL, aVF, or V4-V6
3. Q wave in lead III is not pathologic if Q waves are absent in leads II and aVF
4. Q wave amplitude > 25% of R wave amplitude

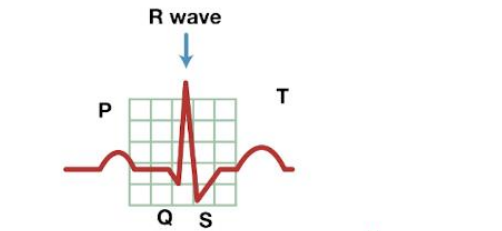


Waves

R wave

Normal Morphology

1. First upward deflection after the P wave
2. R wave is small in V1 and progressively becomes larger in amplitude from V1 to V6 (normal R wave progression)
3. R wave is larger than S wave in V4



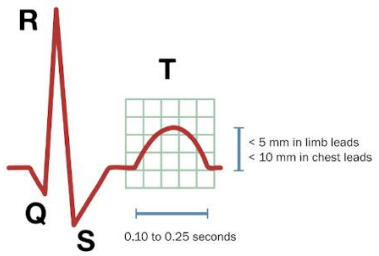
Normal R wave progression from lead V1 to V6

Waves

T wave

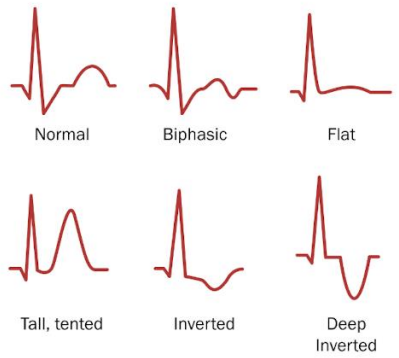
Normal T wave Morphology

1. Represents repolarization of the ventricle
2. Upright in all leads except aVR and V1
3, Amplitude < 5 mm in limb leads, < 10 mm in precordial leads
4. T wave is usually 0.10 to 0.25 seconds or greater and correlates with QT interval

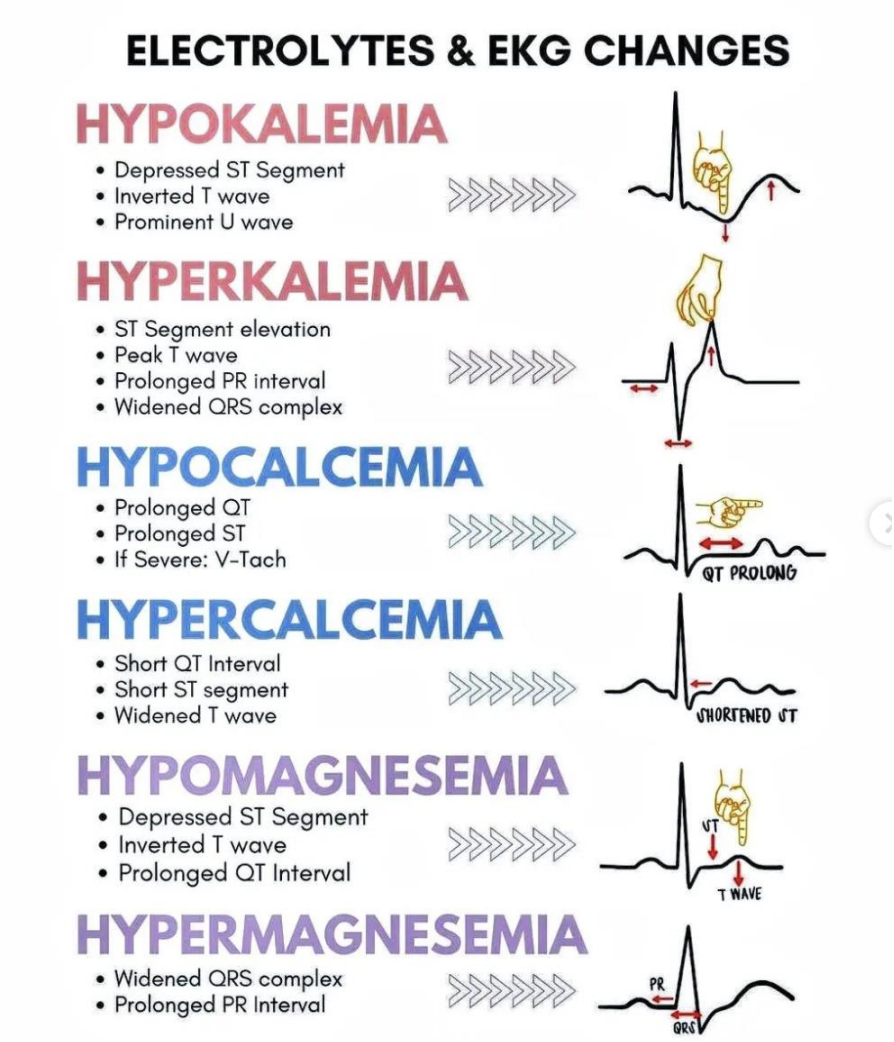


Abnormal T waves

1. Tall tented T waves with narrow base: Seen in hyperkalemia
2. T wave inversions with ST changes are seen in ischemia
3. T wave inversions with tall R waves in V1-V3 can be seen in hypertrophic cardiomyopathy
4. Diffuse T wave inversions in precordial leads can be seen in intracranial hemorrhage
5. T wave inversions can be seen in LVH and bundle branch blocks
6. Biphasic T waves can be seen in ischemia, Wellens syndrome or hypokalemia



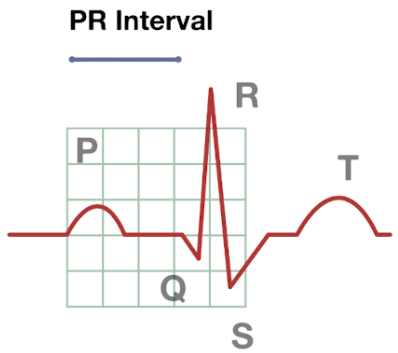
Electrolytes and ECG



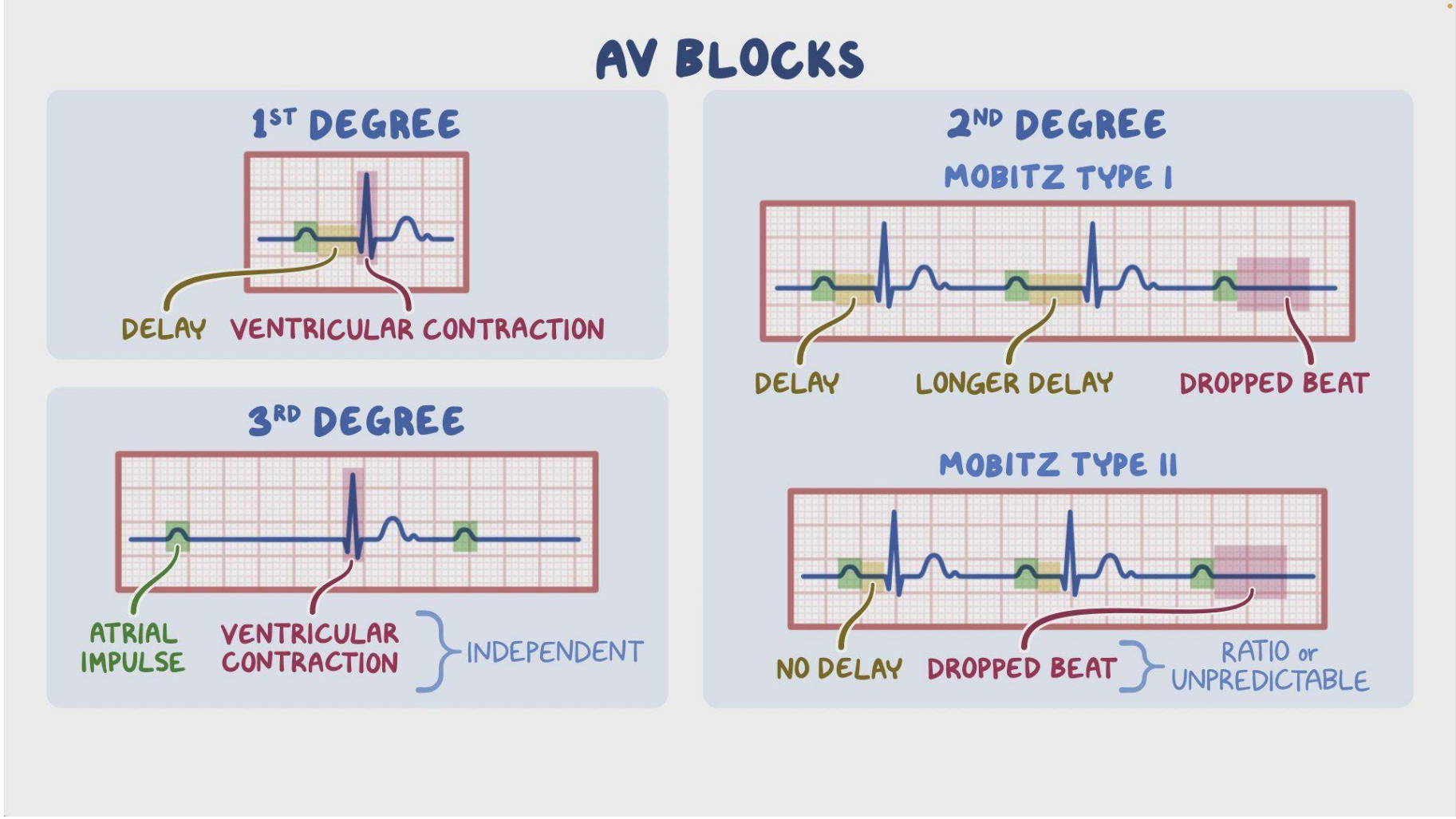
Intervals & Segments

PR interval

1. Time from the onset of the P wave (atrial depolarization) to the start of the QRS complex (ventricular depolarization)
2. Represents: conduction through the AV node
3. Normal PR interval: 120 200 ms (0.12-0.20s or 3 - 5 small squares)
4. lntervals are measured in units of time
5. Shorten with faster heart rates



AV Blocks


AV BLOCKS
1ST DEGREE
DELAY
VENTRICULAR CONTRACTION
3RD DEGREE
ATRIAL IMPULSE
VENTRICULAR CONTRACTION
INDEPENDENT
2ND DEGREE
MOBITZ TYPE I
DELAY
LONGER DELAY
DROPPED BEAT
MOBITZ TYPE II
NO DELAY
DROPPED BEAT
RATIO or UNPREDICTABLE

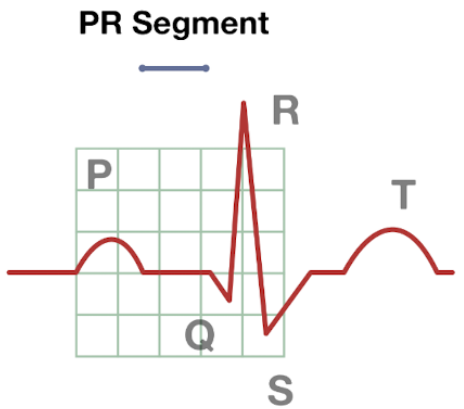
Intervals & Segments

PR segment

1. Isoelectric line between end of the P wave and the start of the QRS complex

2. PR segment depression can be seen in acute pericarditis or atrial infarction

3. Segments are analyzed based on change from the isoelectric line such as elevation or depression

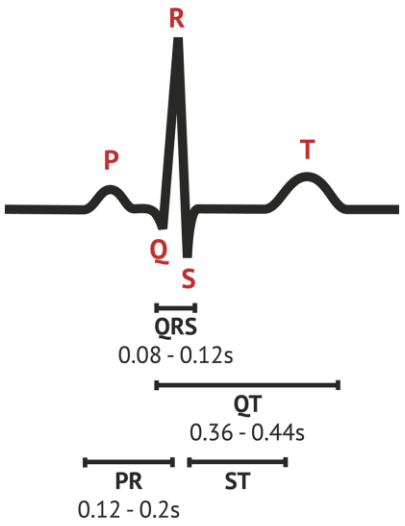


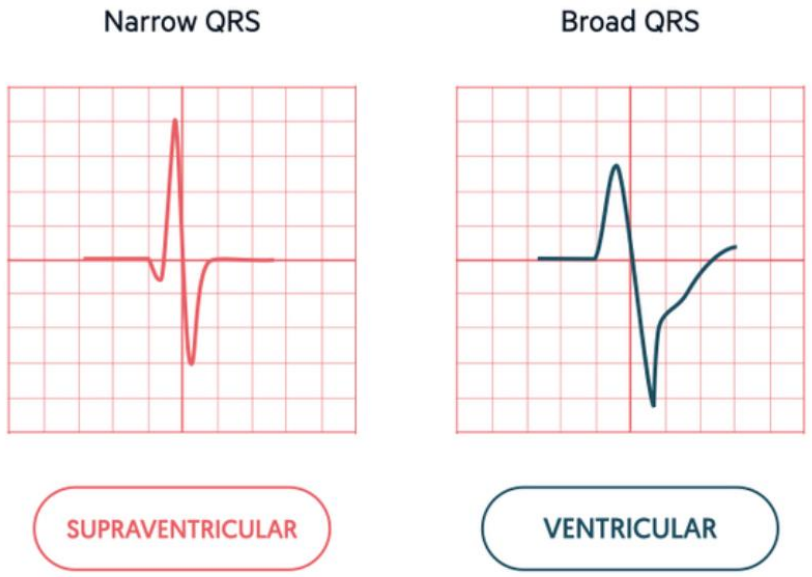
Intervals & Segments

QRS Width

Normal QRS width is 70–100 ms (a duration of 110 ms is sometimes observed in healthy subjects). The QRS width is useful in determining the origin of each QRS complex (e.g. sinus, atrial, junctional or ventricular).

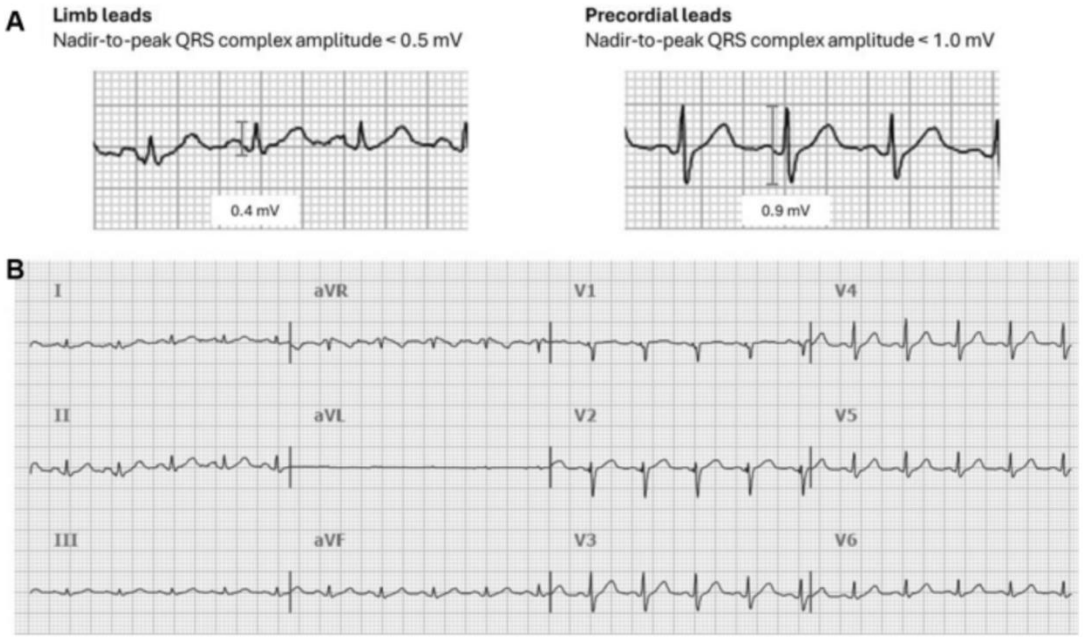
- **Narrow complexes** (QRS < 100 ms) are **supraventricular** in origin.
- **Broad complexes** (QRS > 100 ms) may be either **ventricular** in origin, or due to **aberrant conduction** of supraventricular complexes (e.g. due to bundle branch block, hyperkalaemia or sodium-channel blockade).



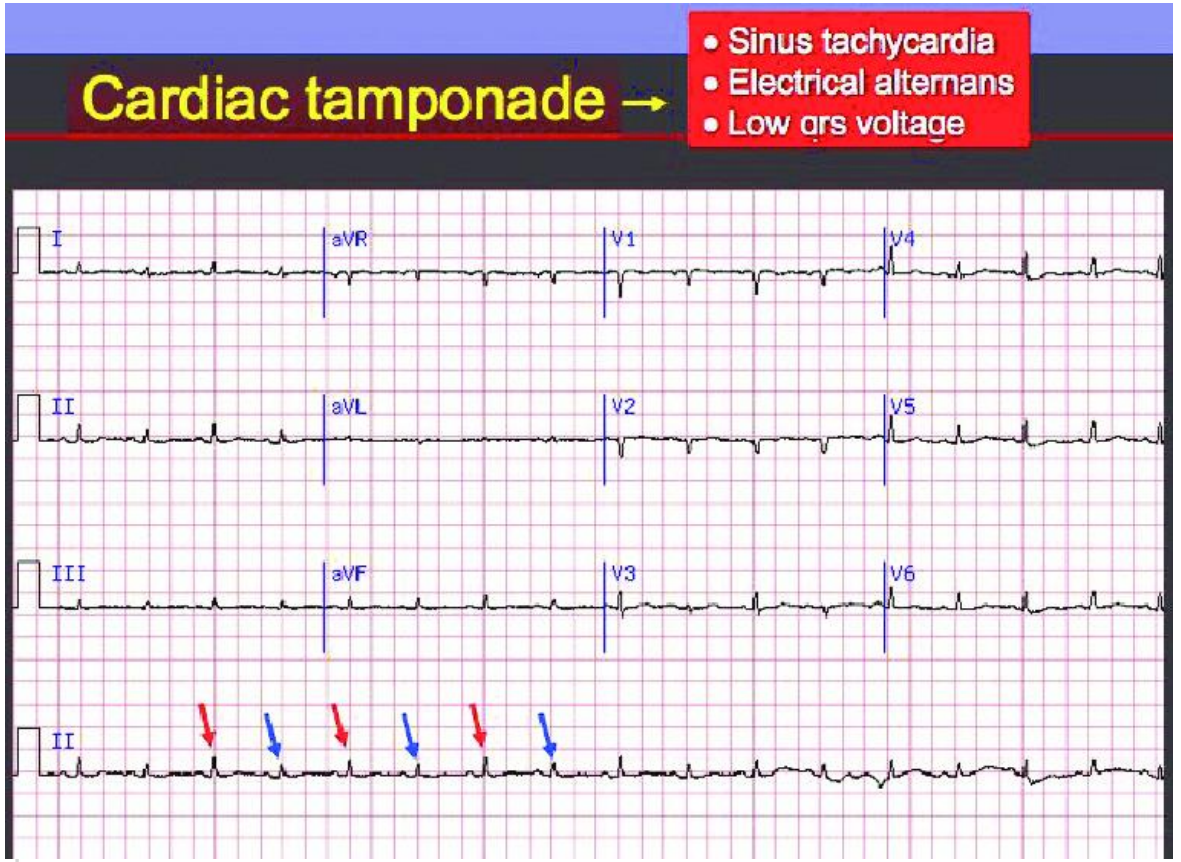


QRS amplitude

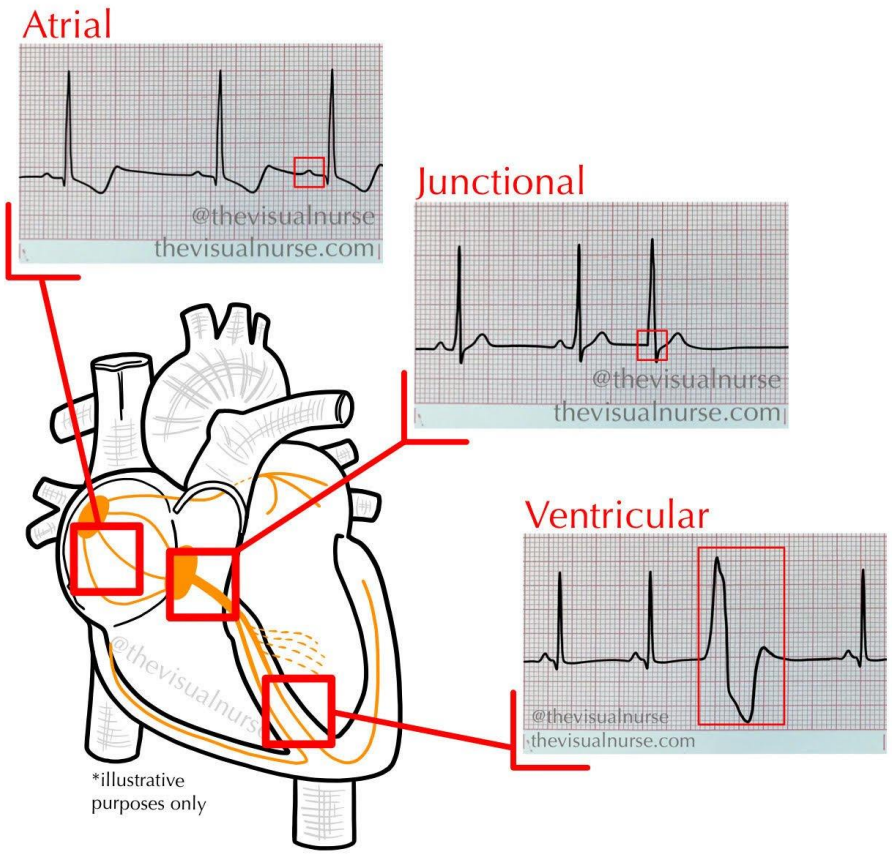
Figure 3

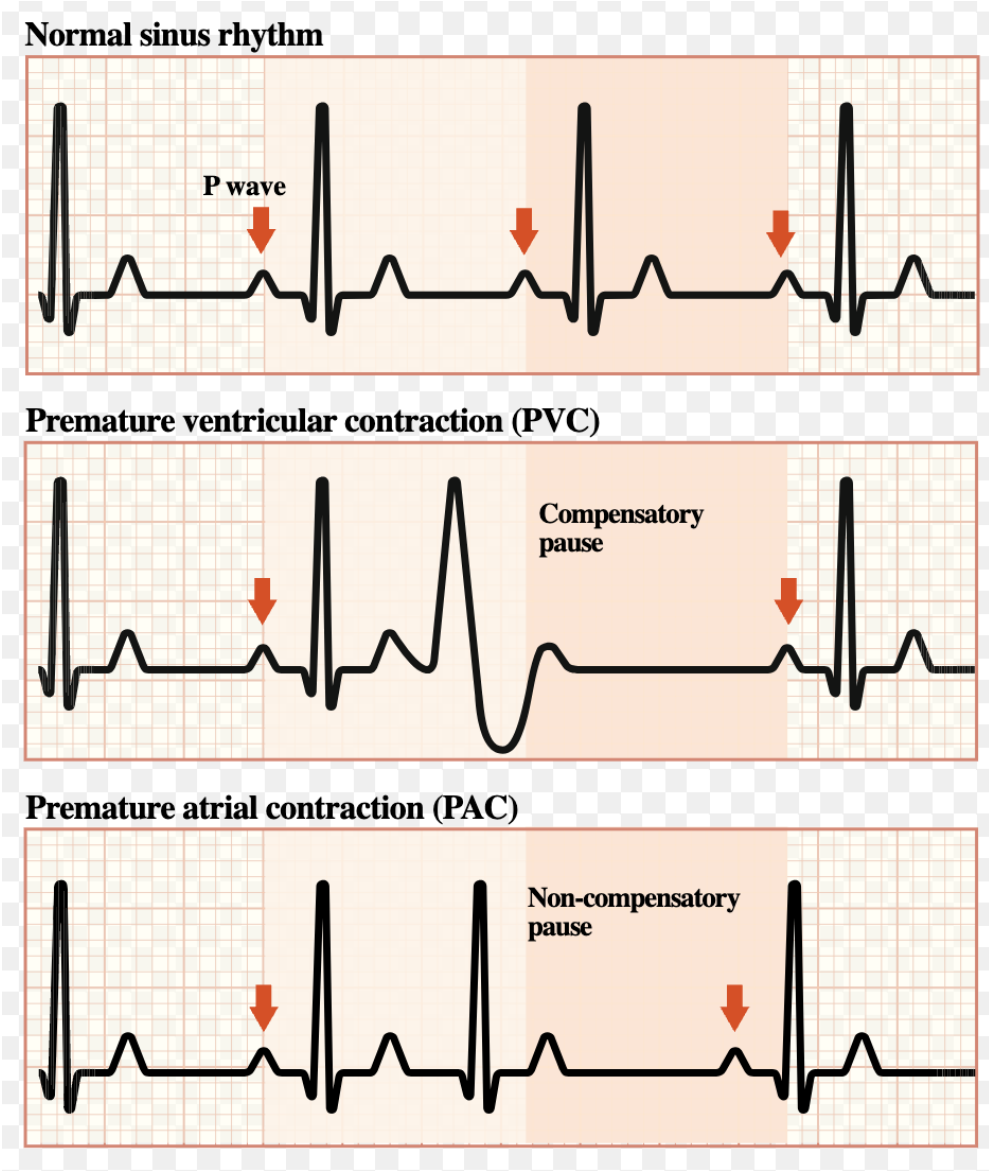


(**A**) definition of low QRS voltage, (**B**) example of 12-lead electrocardiogram showing low QRS voltage in limb leads and precordial leads.



Premature Beats





Intervals & Segments

QT Interval

1. Time from start of Q wave to the end of the T wave

2. Represents: Ventricular depolarisation and repolarisation

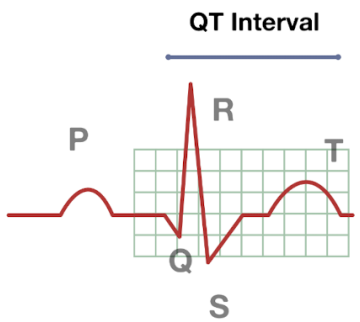
3. Duration: Normal QTc < 440ms in men or < 460ms in women

3. QT interval shortens at faster heart rates

4. QT interval gets prolonged at slower heart rates

5. Measured as the longest interval either in lead II or V5-6

6. Corrected QT or QTc estimates the QT interval at a standard heart rate of 60 bpm. Measured with Bazett formula: QTC = QT / square root of RR



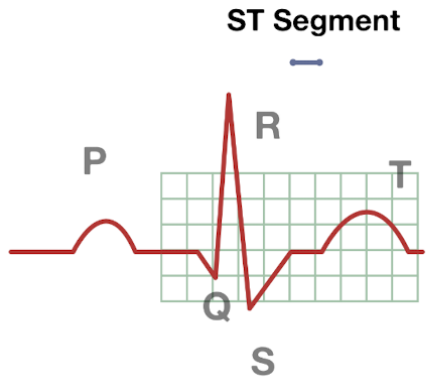
Intervals & Segments

S-T Segment

1. Isoelectric line between the end of the S wave (the J point) and the beginning of the T wave

2. Represents: Interval between ventricular depolarization and repolarization

3. ST segment changes can be seen in ischemia, electrolyte abnormalities and multiple other conditions



Intervals & Segments

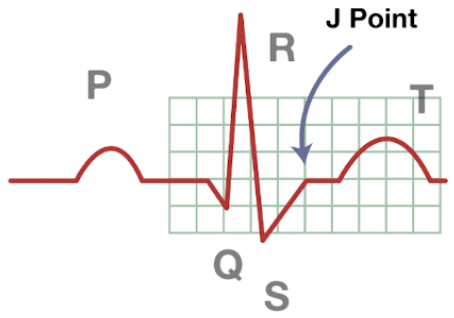
J point

1. Junction between the termination of the QRS complex and the beginning of the ST segment

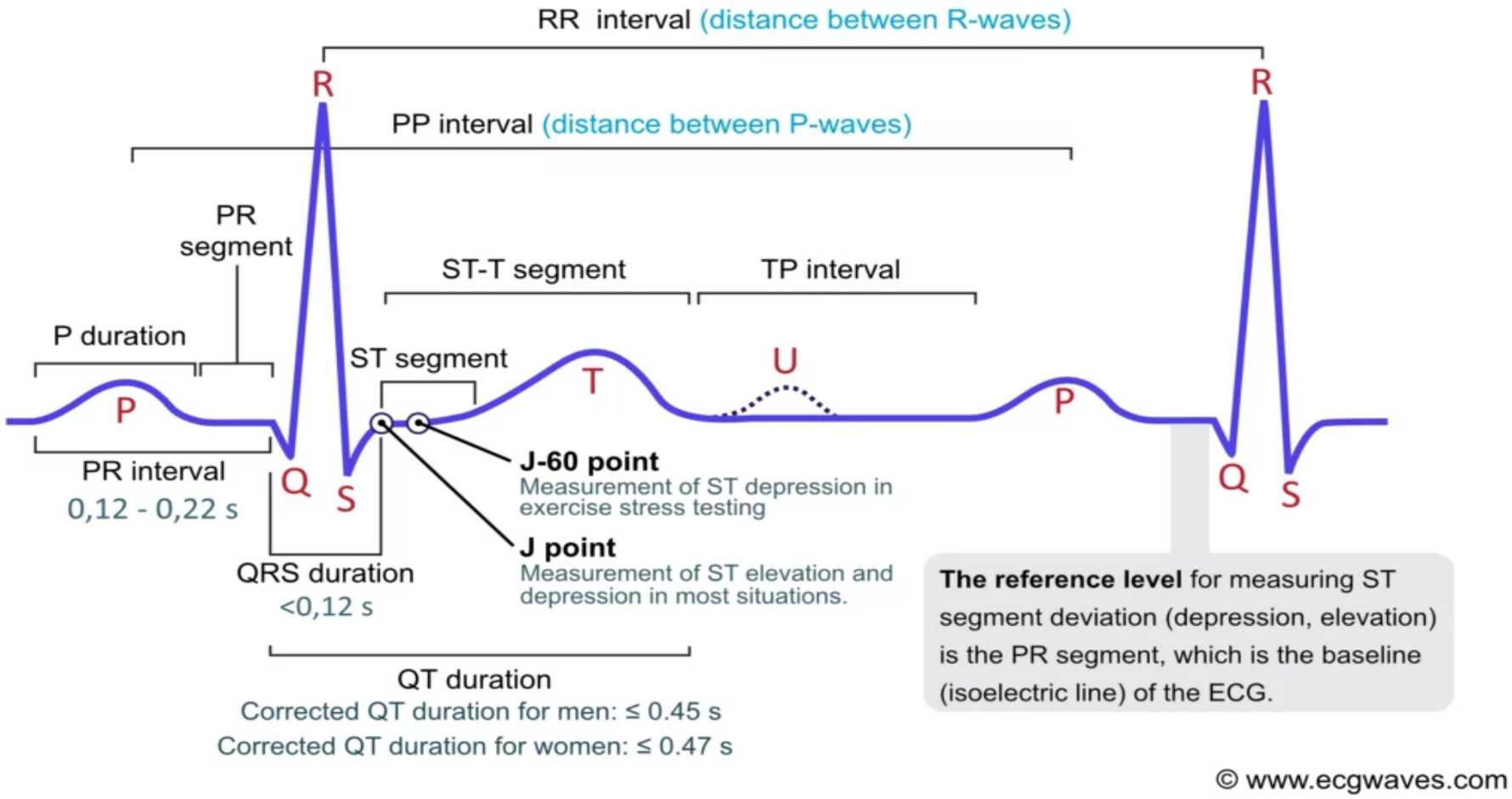
2. Represents end of depolarization

3. Elevation or depression of the J point is usually seen with ST segments changes such as in ischemia

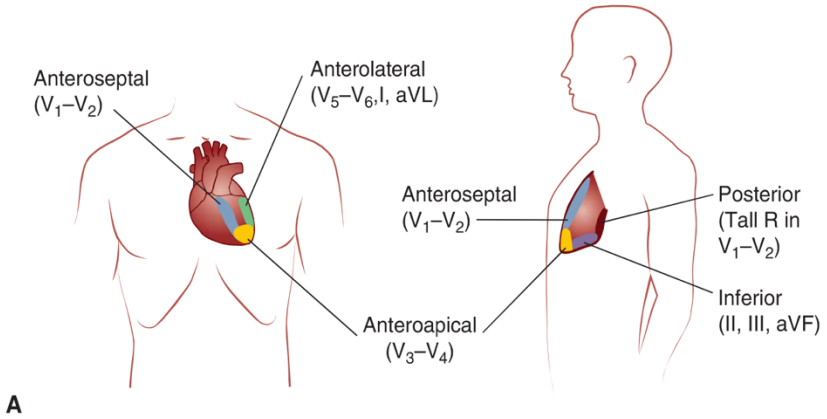
4. J point elevation can also be seen in early repolarization



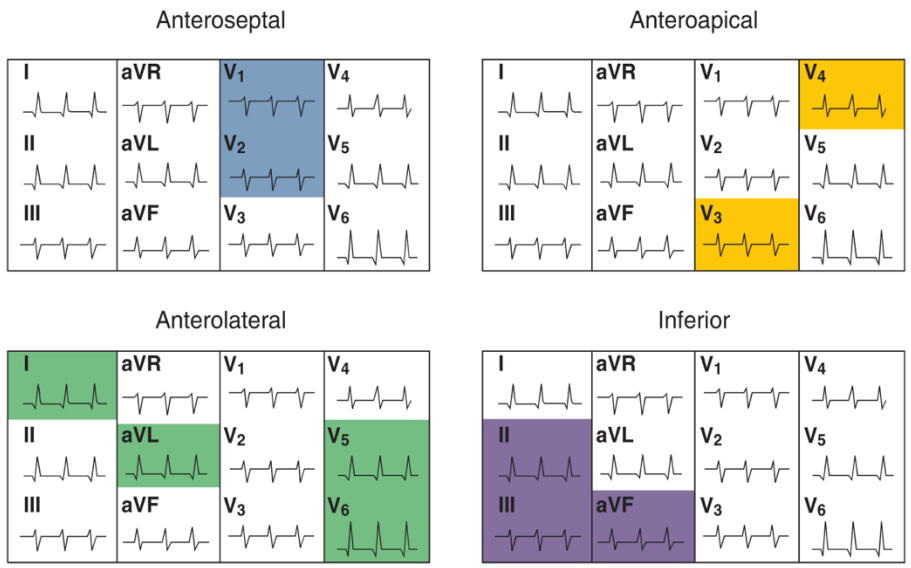
All Together



Ischemia, Hypertrophy, Bundle Branch Blocks



A



B

FIGURE 4-23. Relationship between ECG leads and cardiac anatomic regions. A. The lead groupings listed

TABLE 4-4 Localization of Myocardial Infarction

Anatomic Site	Leads with Abnormal ECG Complexes[a]	Coronary Artery Most Often Responsible
Inferior	II, III, aV_F	RCA
Anteroseptal	V_1–V_2	LAD
Anteroapical	V_3–V_4	LAD (distal)
Anterolateral	V_5–V_6, I, aV_L	CFX
Posterior	V_1–V_2 (tall R wave, not Q wave)	RCA

[a]Pathologic Q waves in all of leads V_1–V_6 implies an "extensive anterior MI" usually associated with a proximal left coronary artery occlusion.

CFX, left circumflex coronary artery; LAD, left anterior descending coronary artery; RCA, right coronary artery.

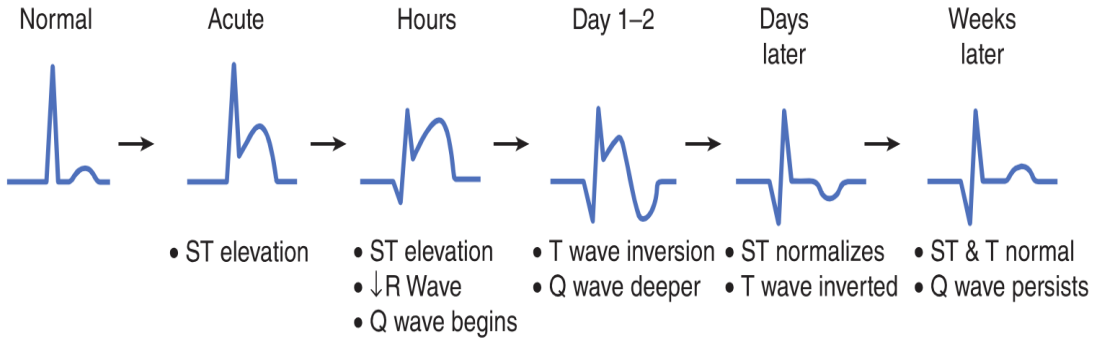


FIGURE 4-24. ECG evolution during acute ST-elevation myocardial infarction. However, as described in Chapter 7, if successful early reperfusion of the coronary occlusion is achieved, the initially elevated ST segment returns to baseline without subsequent T-wave inversion or Q-wave development.

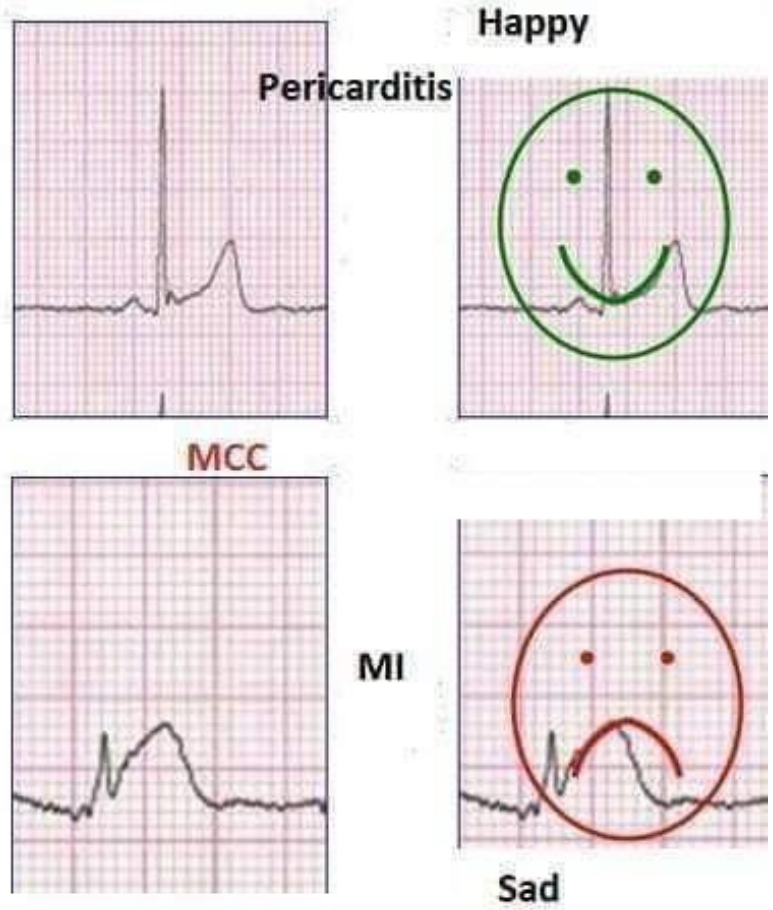
Ischemia vs Pericarditis

EMNote

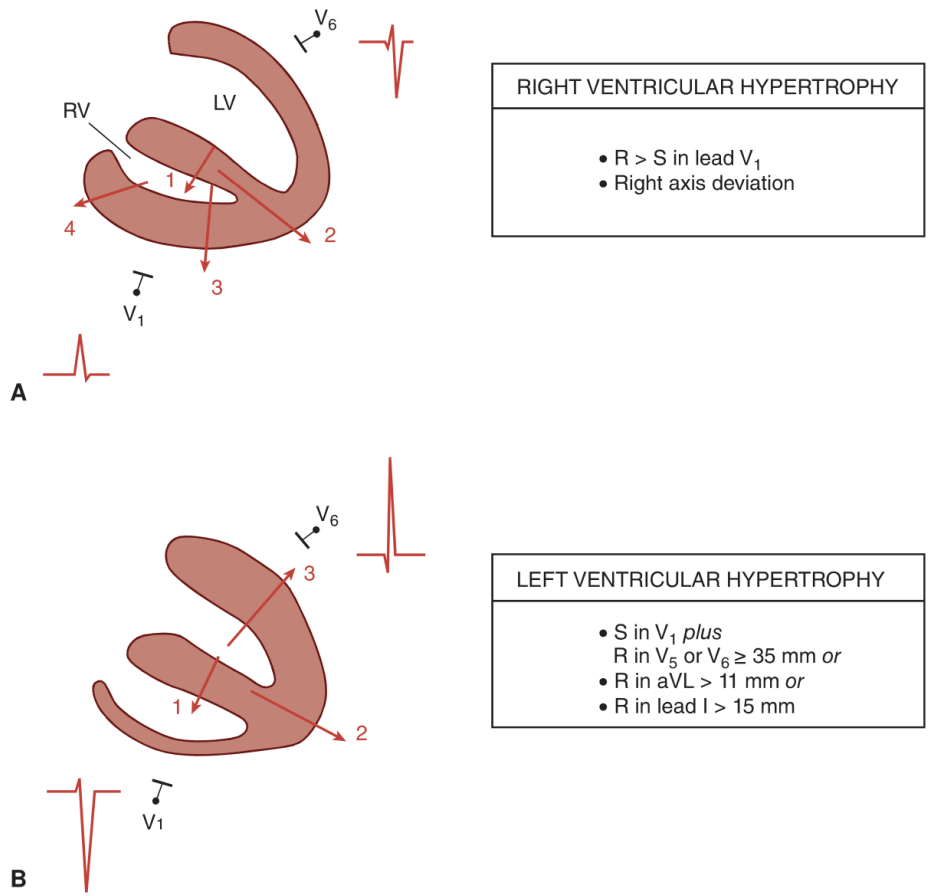
ECG findings of PERICARDITIS

1. Widespread concave ST elevation
   - No convex or horizontal ST elevation
   - ST elevation in II > III
2. Widespread PR depression
3. ST depression and PR elevation in aVR ± V1
   - No ST depression in any lead other than aVR or V1
4. Spodick's sign positive
   - downsloping of TP segment

@ jackcfchong



Ischemia, Hypertrophy, Bundle Branch Blocks



RIGHT VENTRICULAR HYPERTROPHY

- R > S in lead V_1
- Right axis deviation

LEFT VENTRICULAR HYPERTROPHY

- S in V_1 *plus* R in V_5 or $V_6 \geq 35$ mm *or*
- R in aVL > 11 mm *or*
- R in lead I > 15 mm

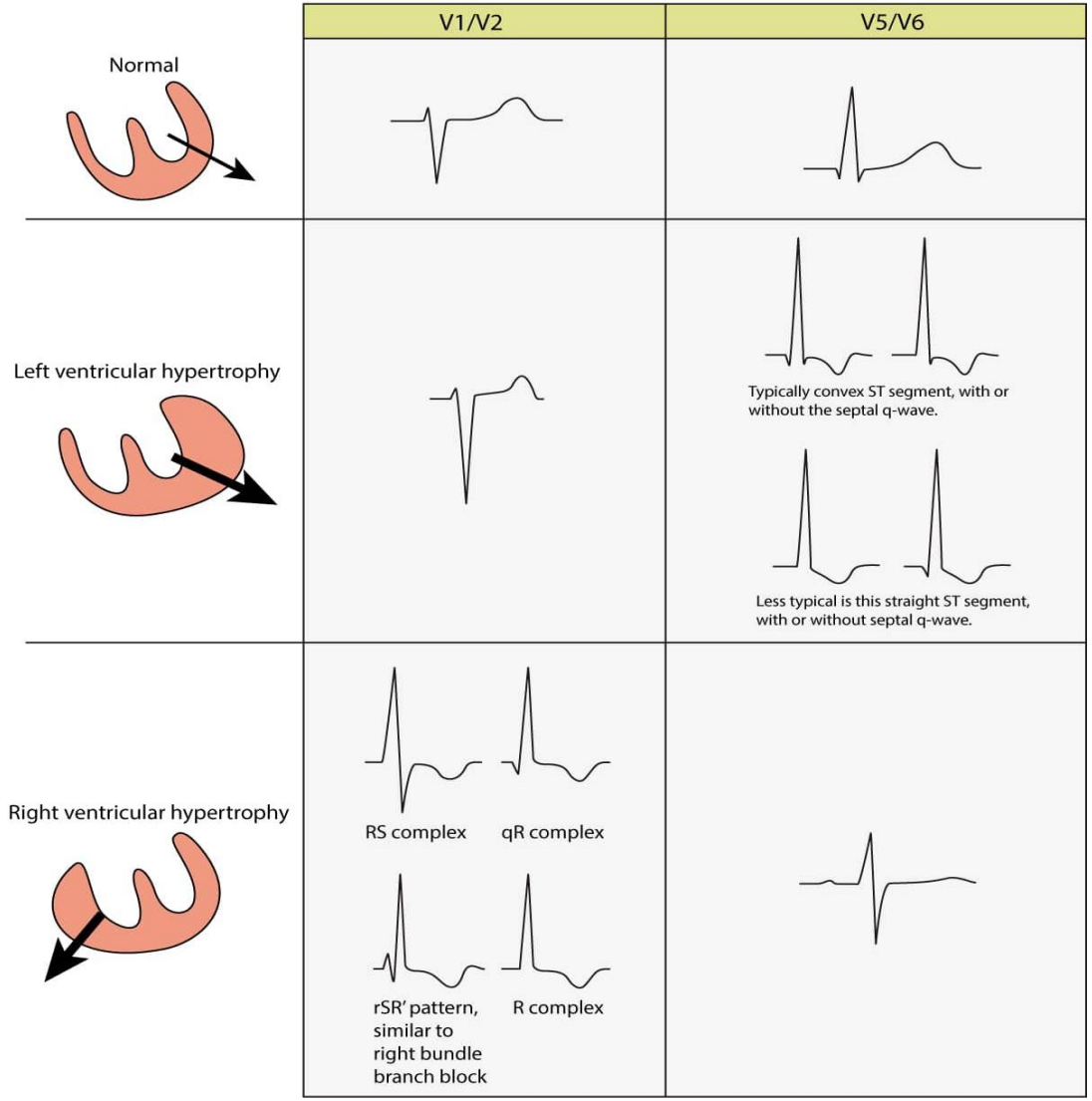


FIGURE 4-18. Ventricular hypertrophy. The *arrows* indicate the sequence of average electrical forces during ventricular depolarization. **A.** Right ventricular (RV) hypertrophy. The RV forces outweigh those of the left, resulting in tall R waves in leads V_1 and V_2 and a deep S wave in lead V_6 (compare to normal QRS complexes in Fig. 4-11E). **B.** Left ventricular (LV) hypertrophy exaggerates the normal pattern of depolarization, with greater-than-normal forces directed toward the LV, resulting in a tall R wave in V_6 and a deep S wave in lead V_1.

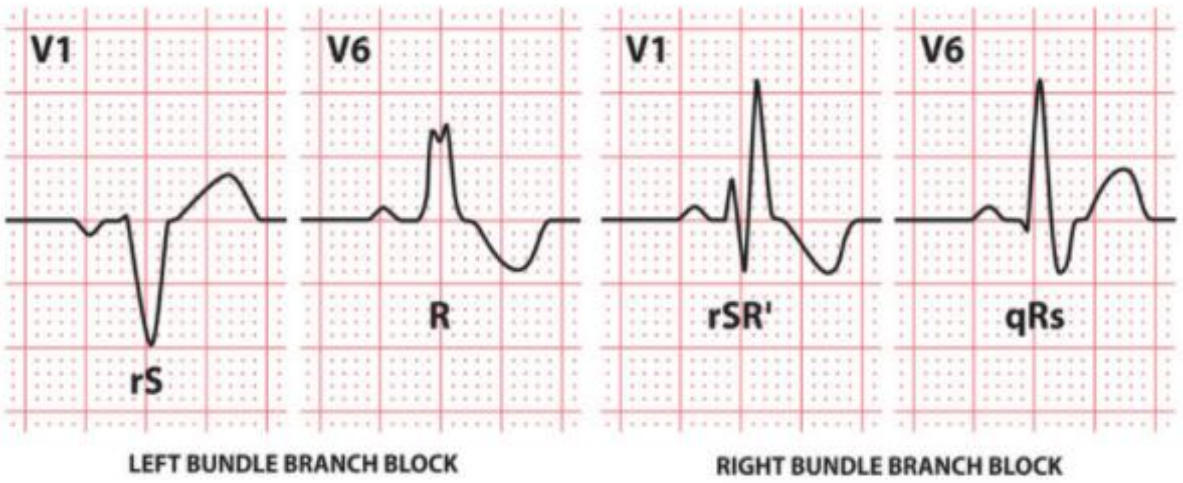
LVH Criteria

- Sokolow + Lyon
  - S V1+ R V5 or V6 > 35 mm
- Cornell criteria *(Circulation, 1987;3: 565-72)*
  - S V3 + R avl > 28 mm in men
  - S V3 + R avl > 20 mm in women
- Framingham criteria *(Circulation,1990; 81:815-820)*
  - R avl > 11mm, R V4-6 > 25mm
  - S V1-3 > 25 mm, S V1 or V2 +
  - R V5 or V6 > 35 mm, R I + S III > 25 mm
- Romhilt + Estes *(Am Heart J, 1986:75:752-58)*
  - Point score system

Ischemia, Hypertrophy, Bundle Branch Blocks

Left vs. Right Bundle Branch Block

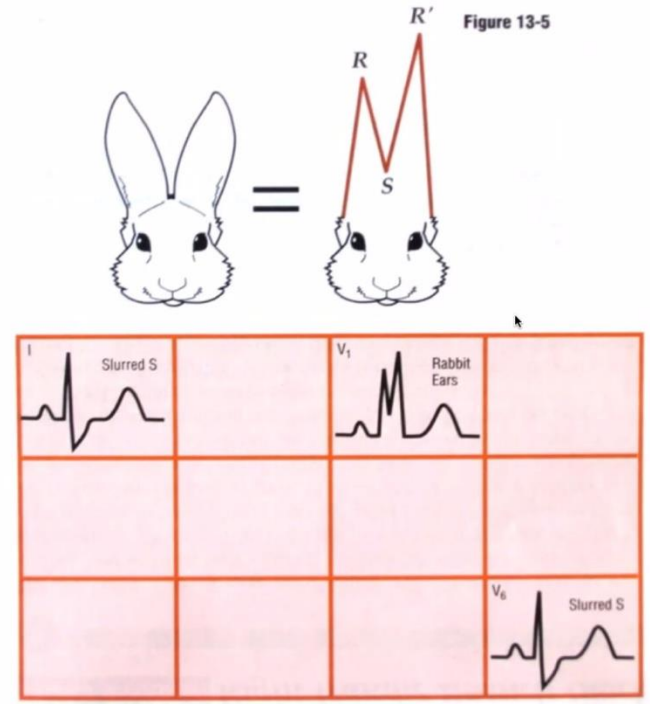
WiLLiaM MaRRoW



W pattern in V1 and M pattern in V6 = LBBB

M pattern in V1 and W pattern in V6 = RBBB

RBBB - EKG Diagnosis



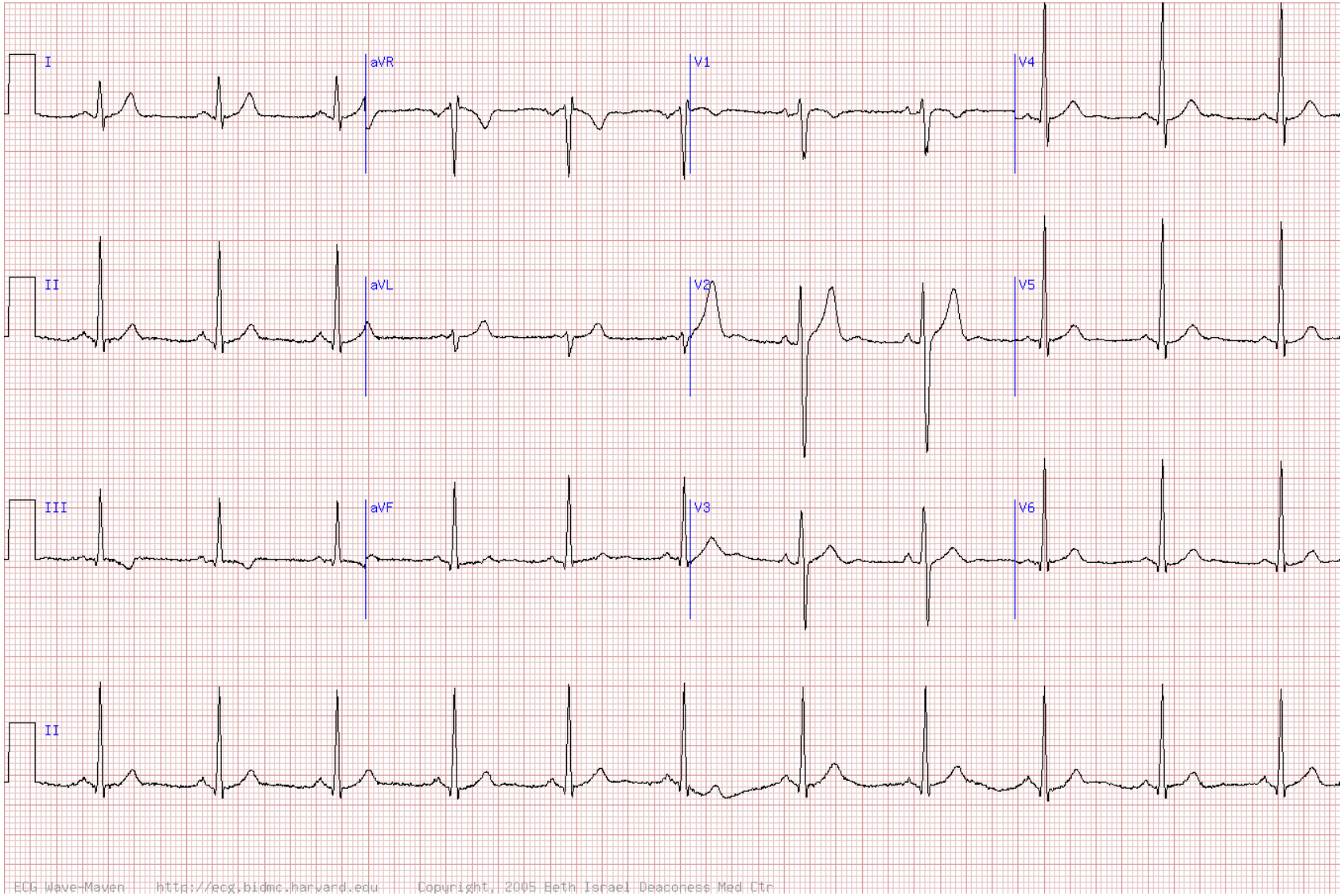
EKG Criteria:

- QRS > 0.12 seconds
- Slurred S in I and V6
- RSR' or notched R in V1

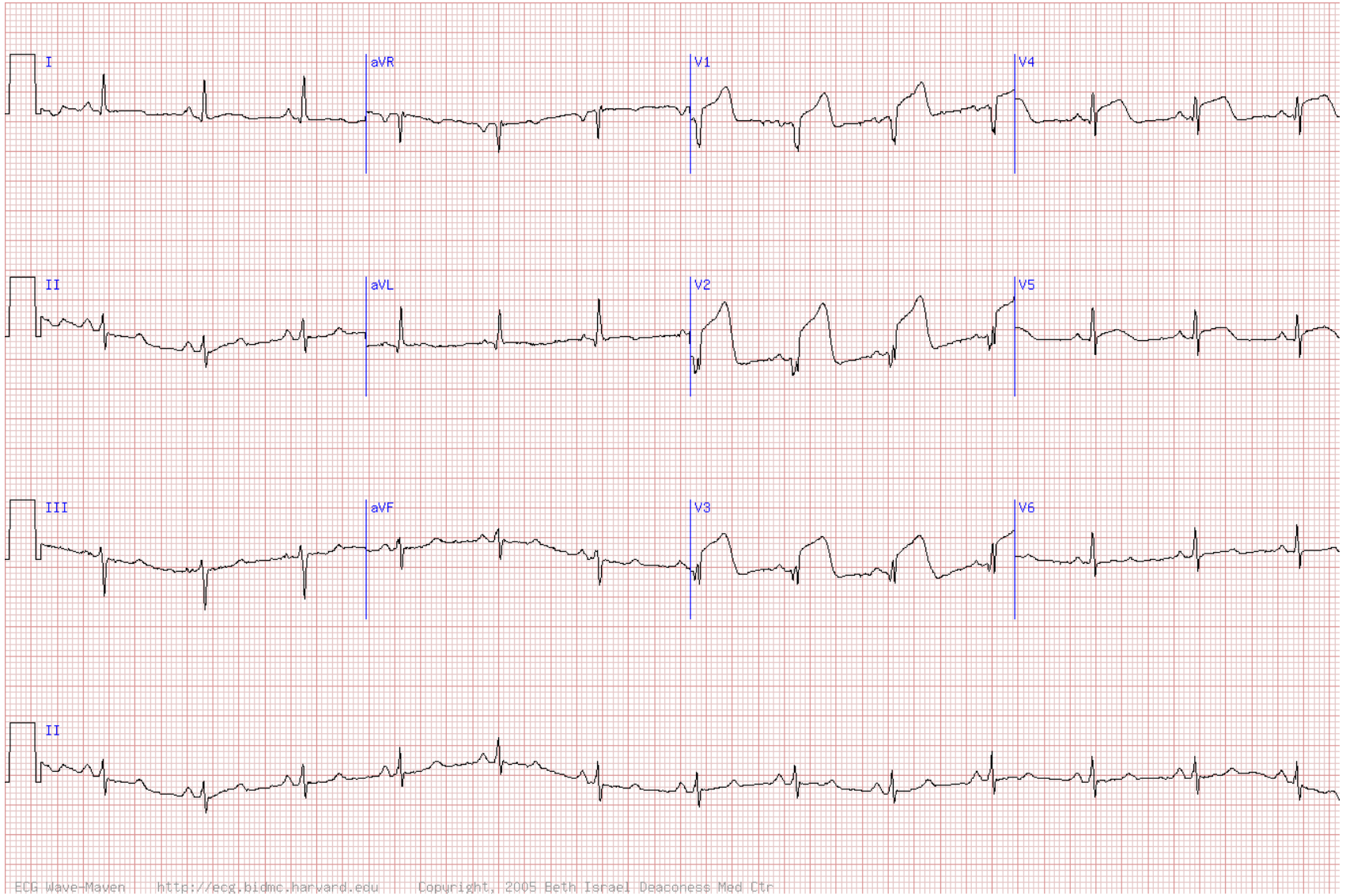
ECG Interpretation: Systematic Approach

1. Rate
2. Rhythm
   - Regular?
   - Sinus?
3. Axis
4. Waves/Segments/Intervals
5. Ischemia/Hypertrophy/ other
6. Clinical Diagnosis?

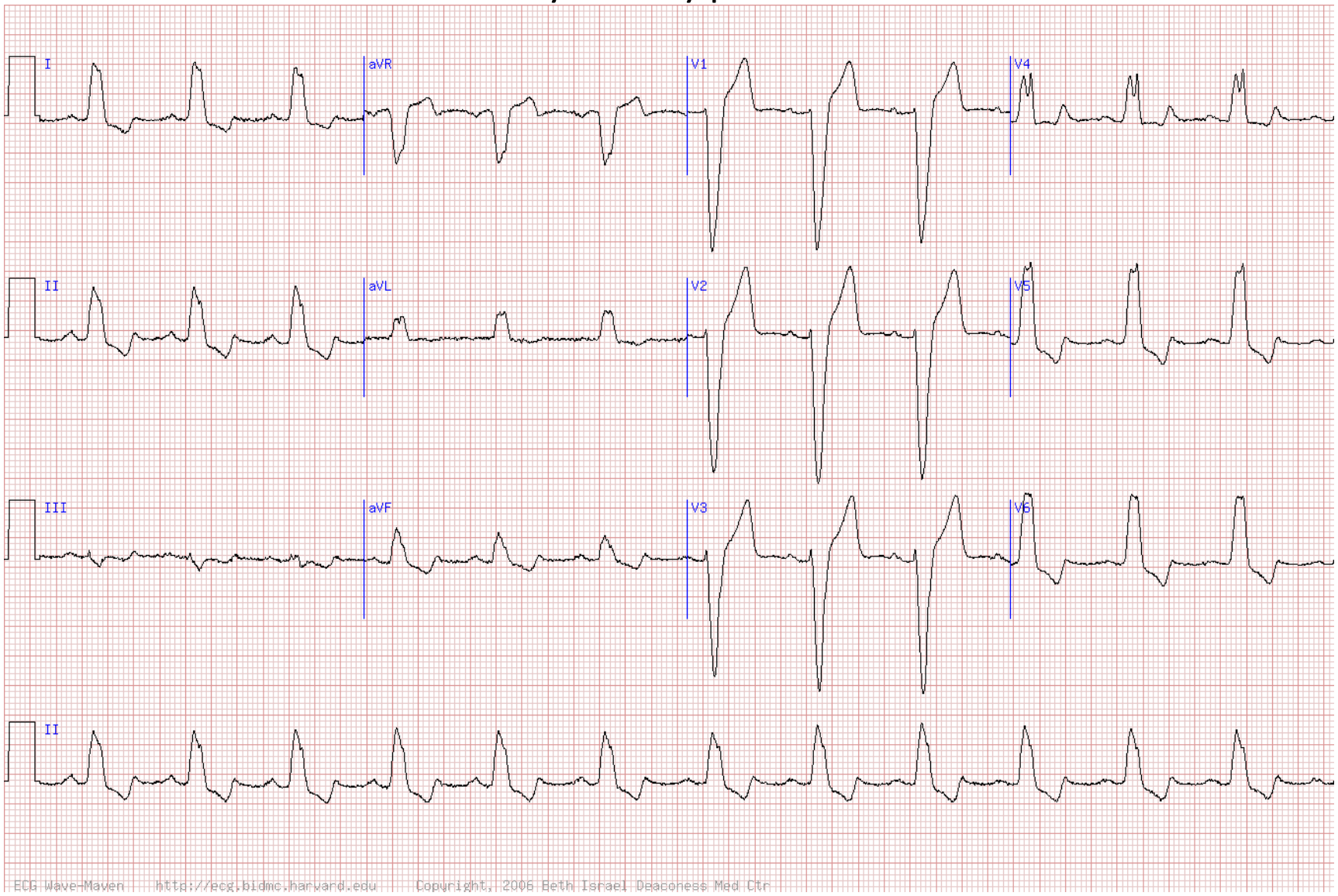
26 year old healthy man



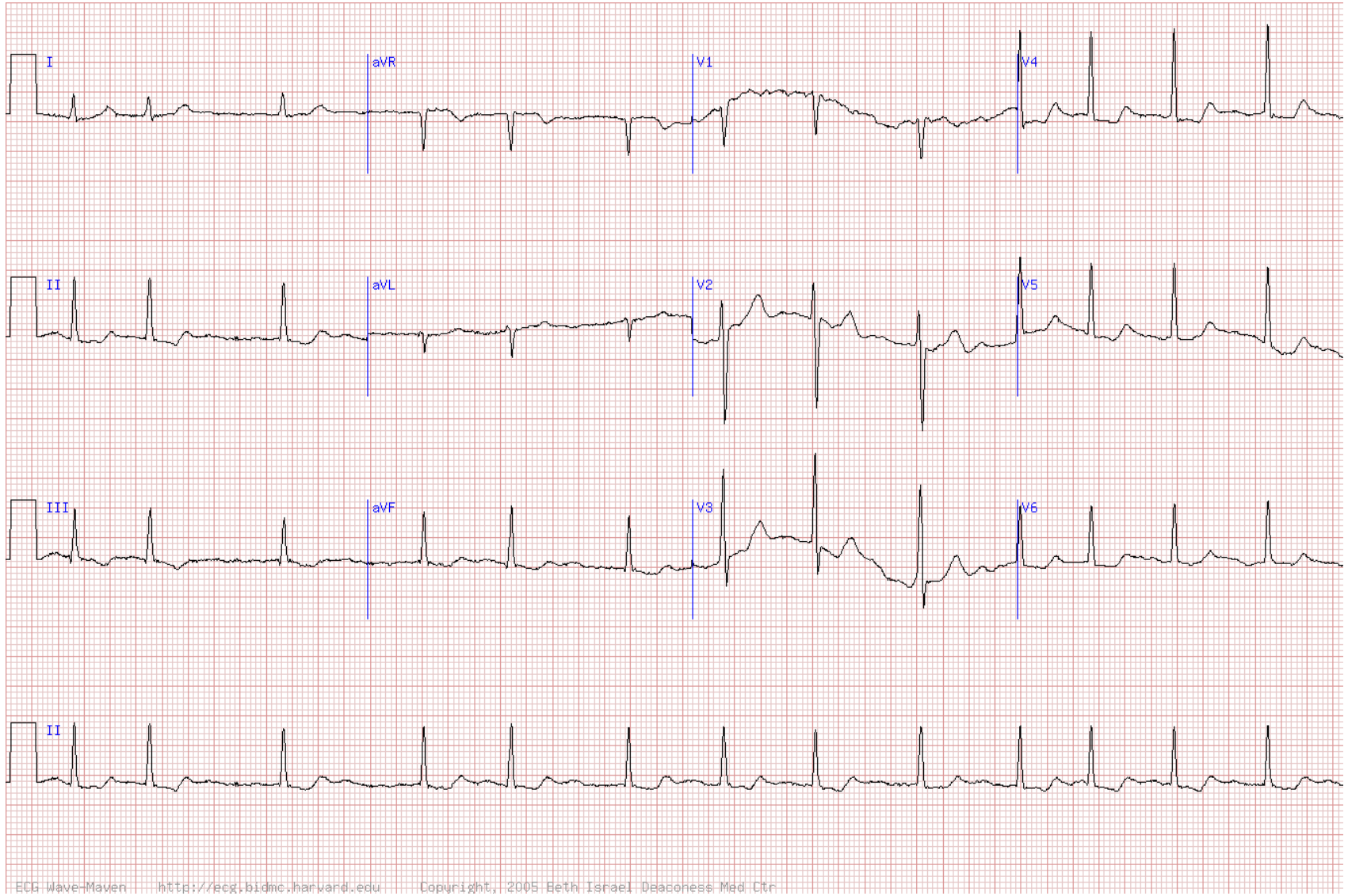
47 year old man with chest pain



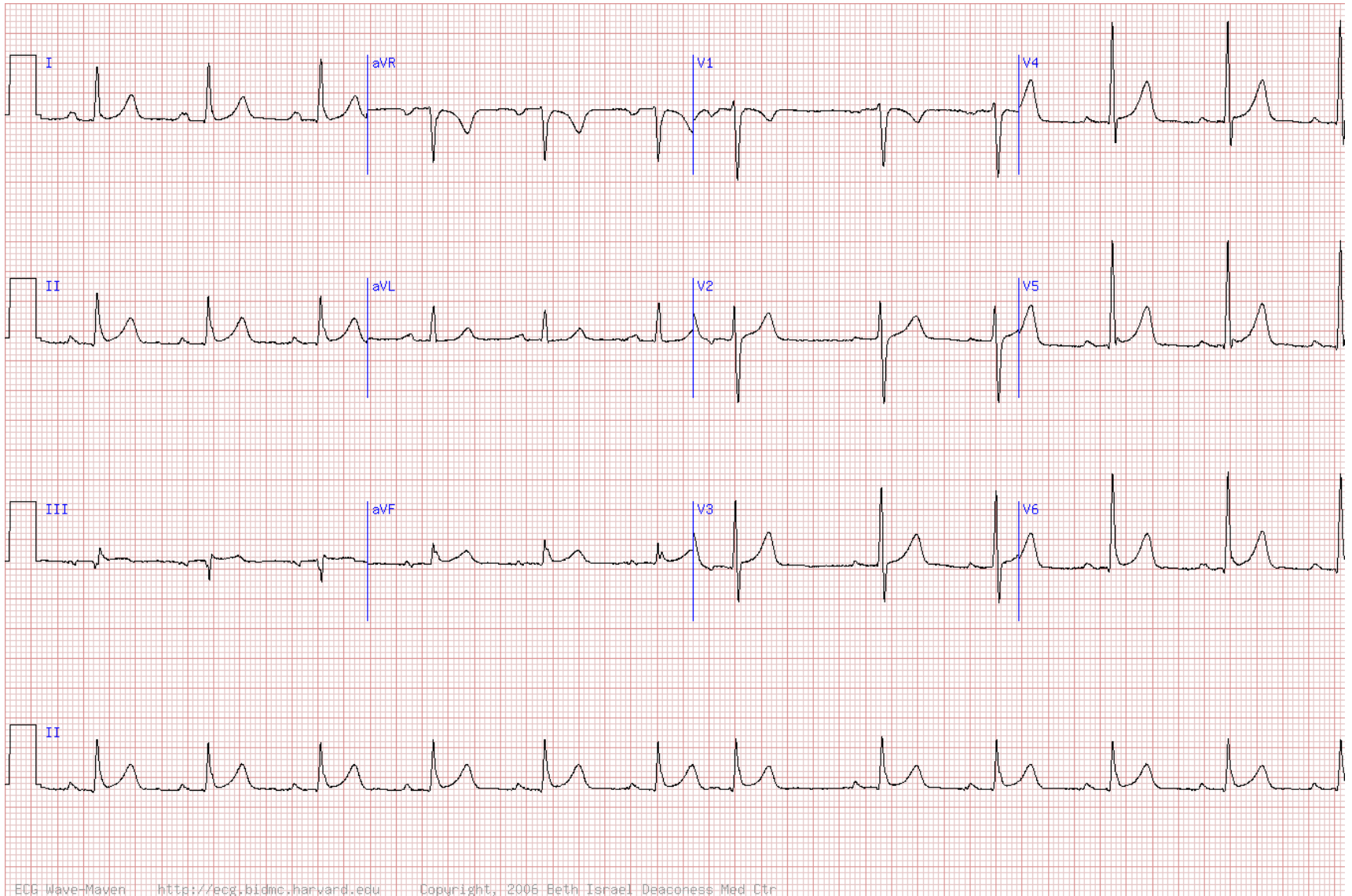
Elderly healthy patient



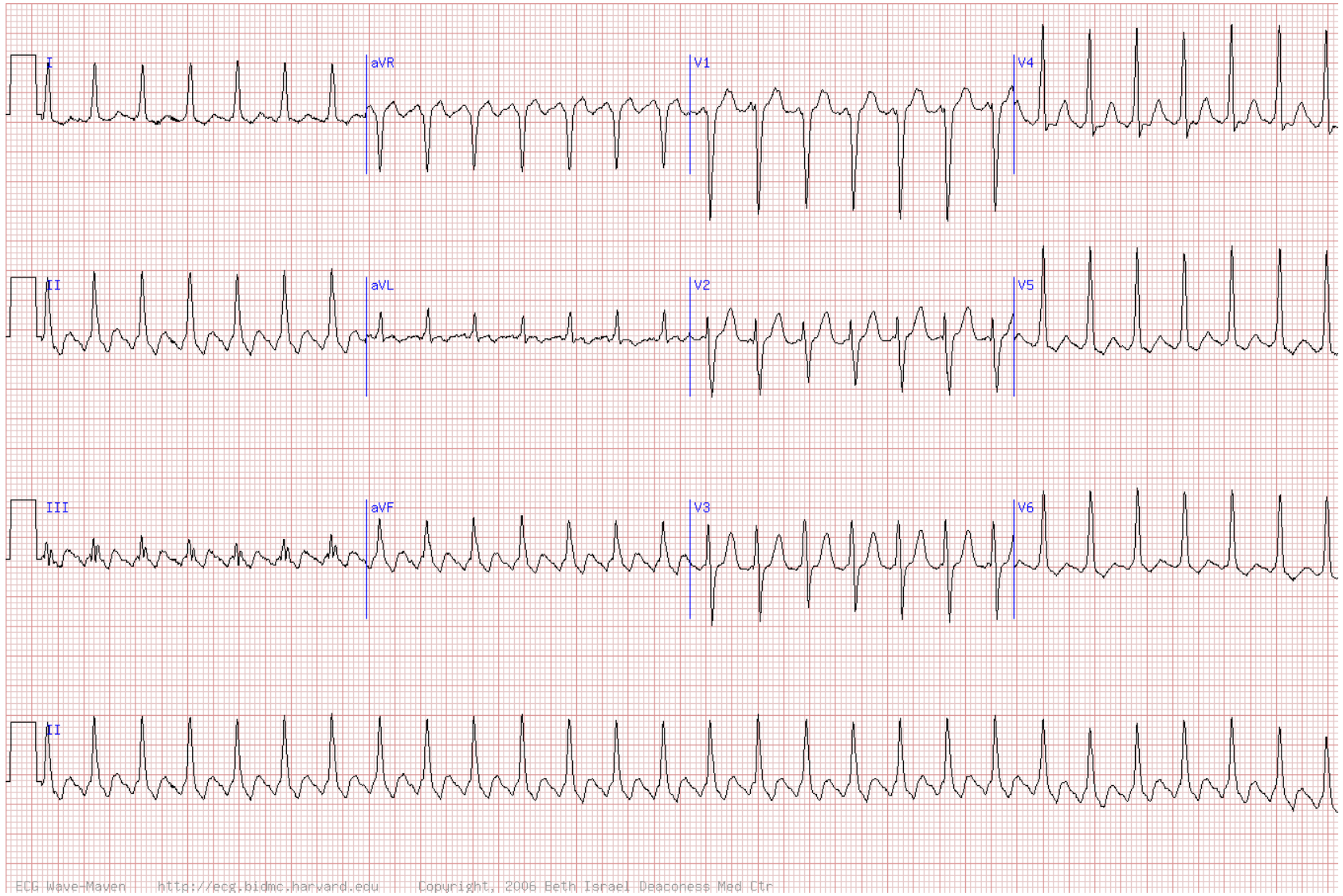
Elderly patient taking Digoxin



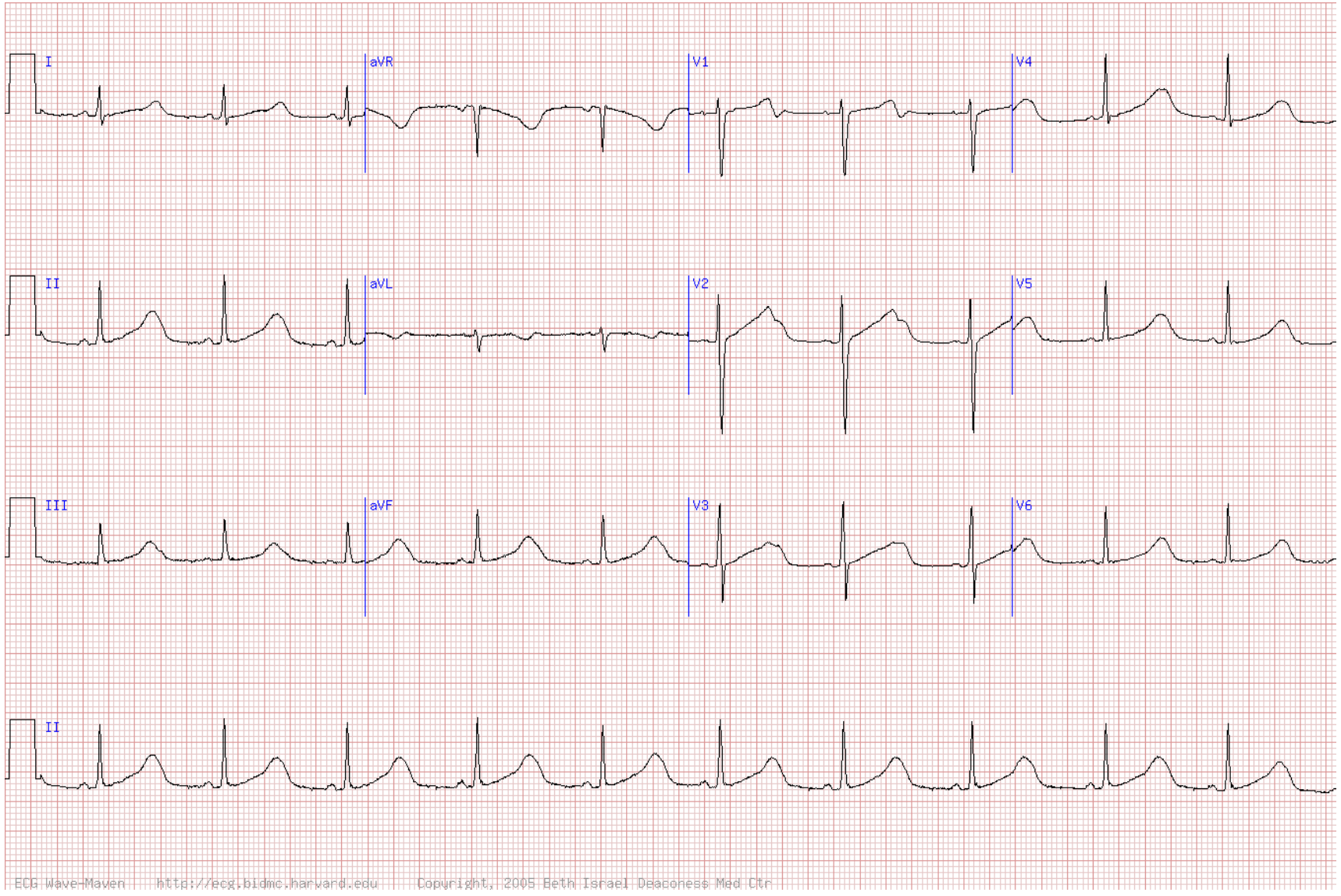
40 year old woman with palpitations



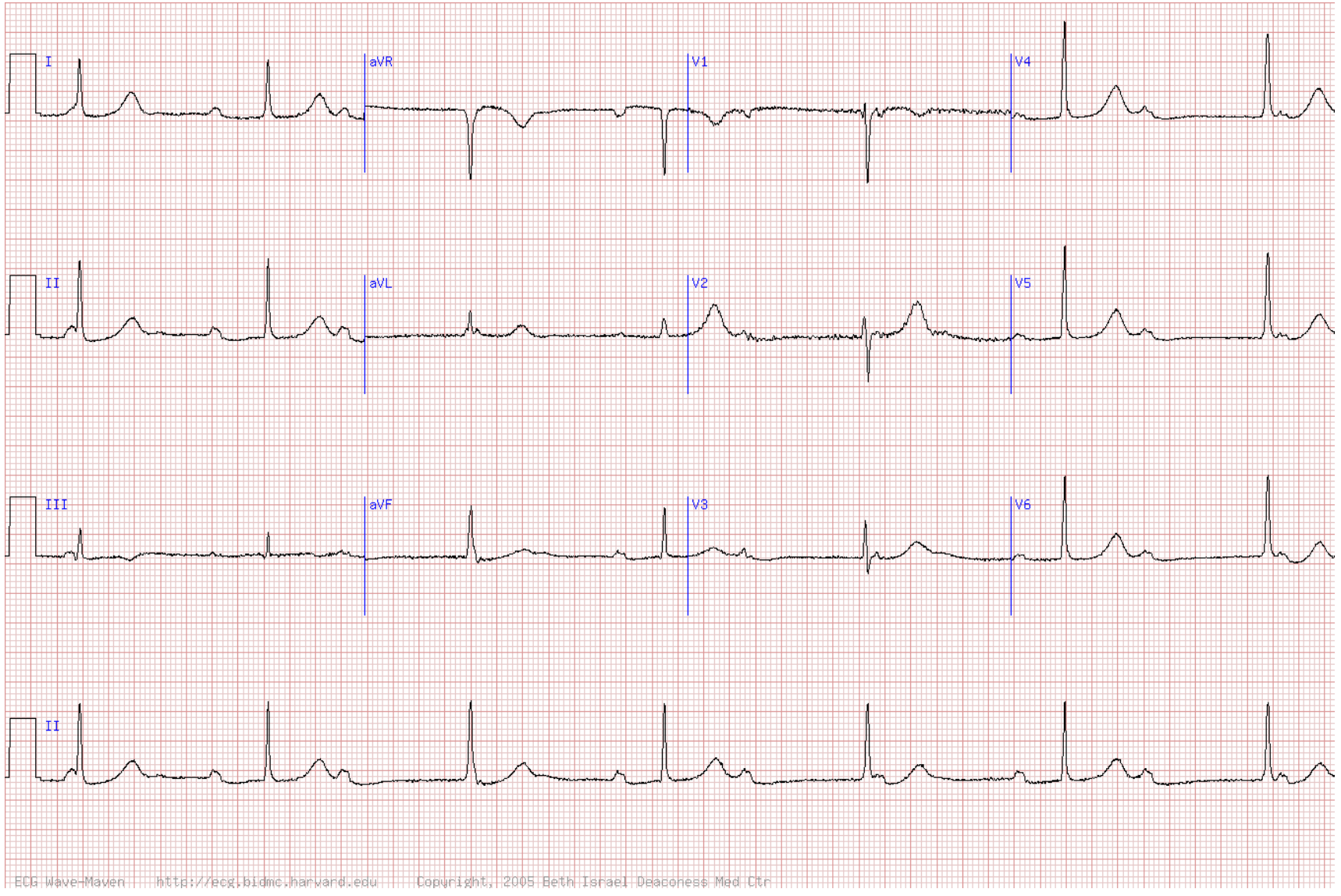
86 year old man with palpitations and shortness of breath



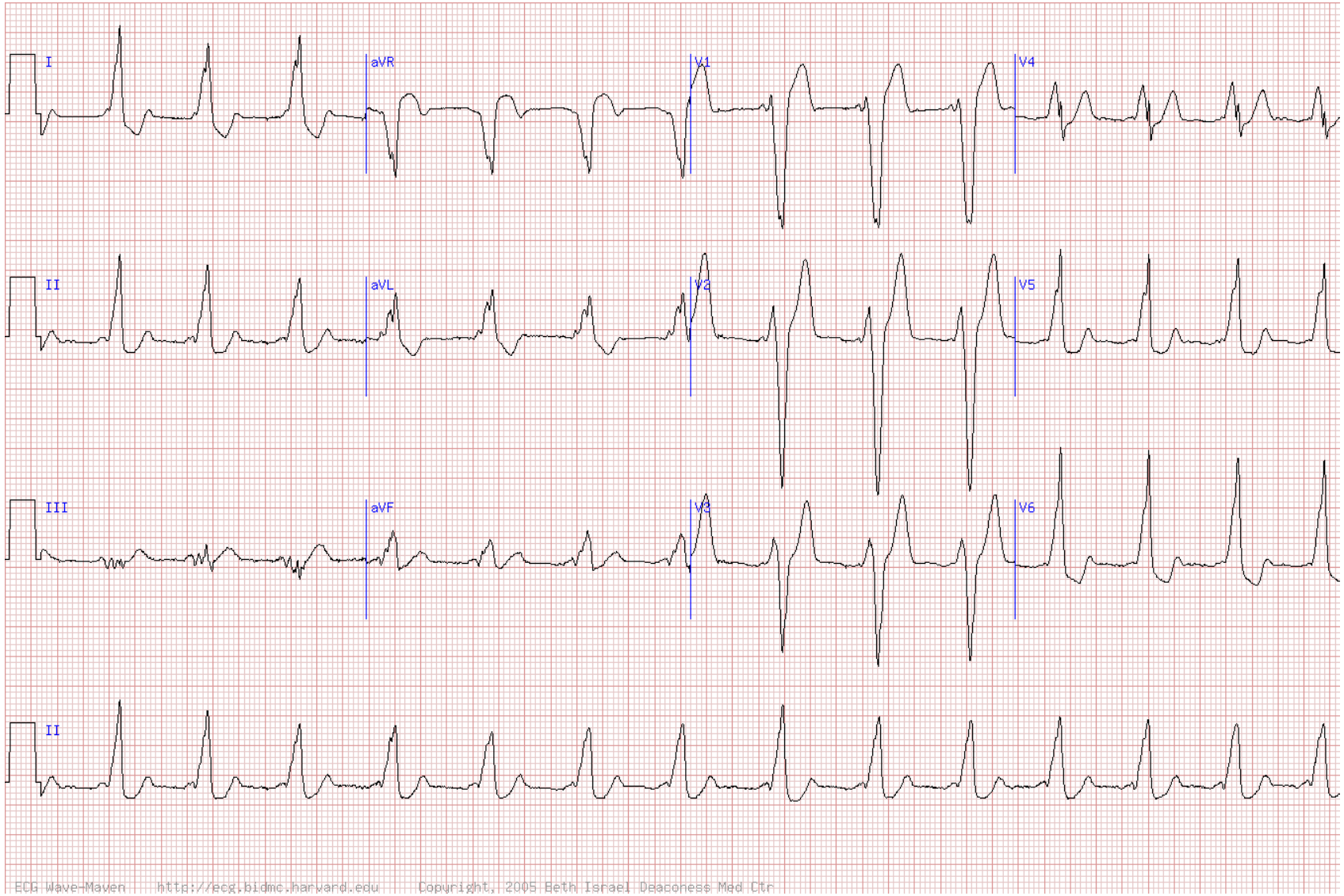
21 year old woman with “seizures”



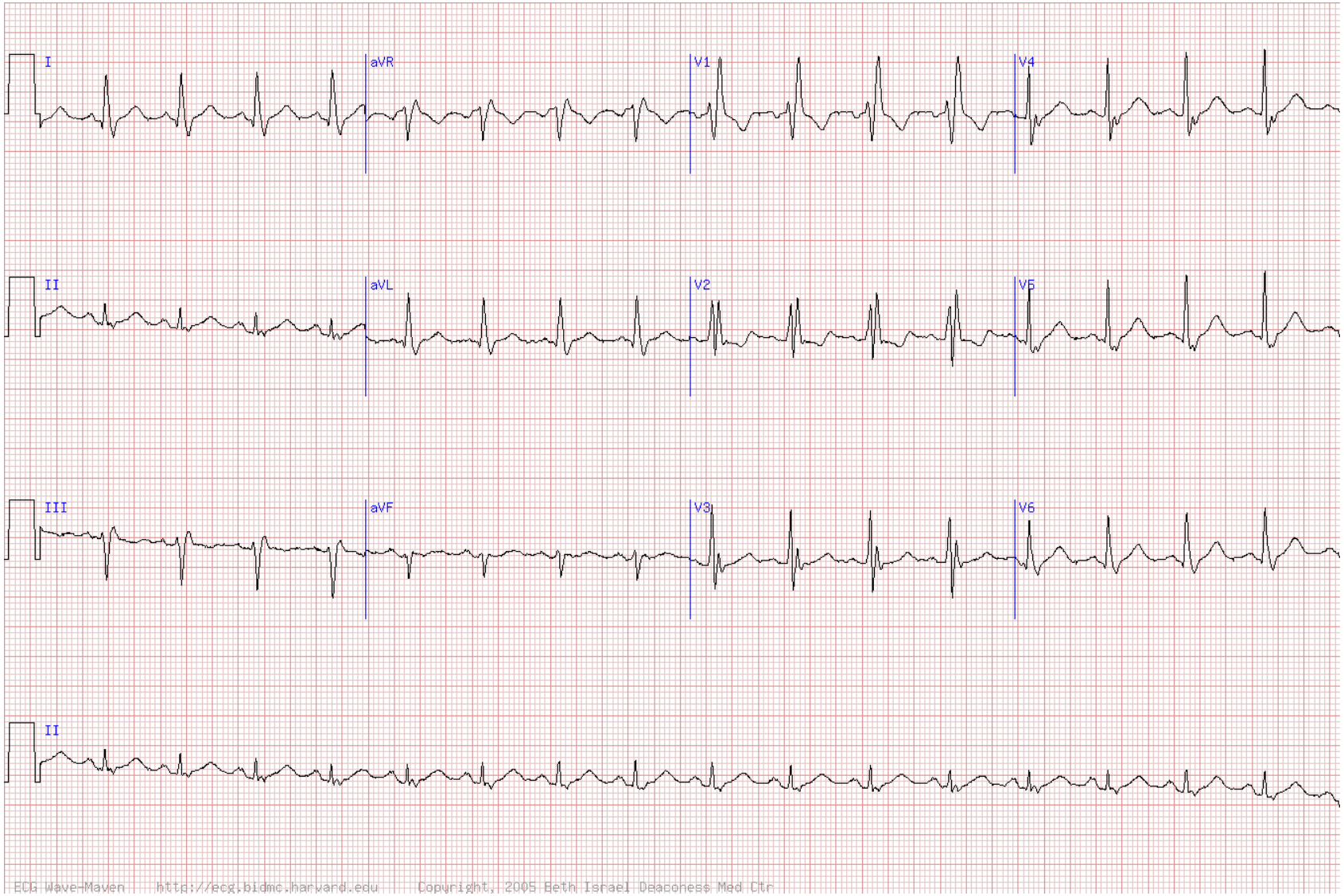
81 year old woman with fatigue



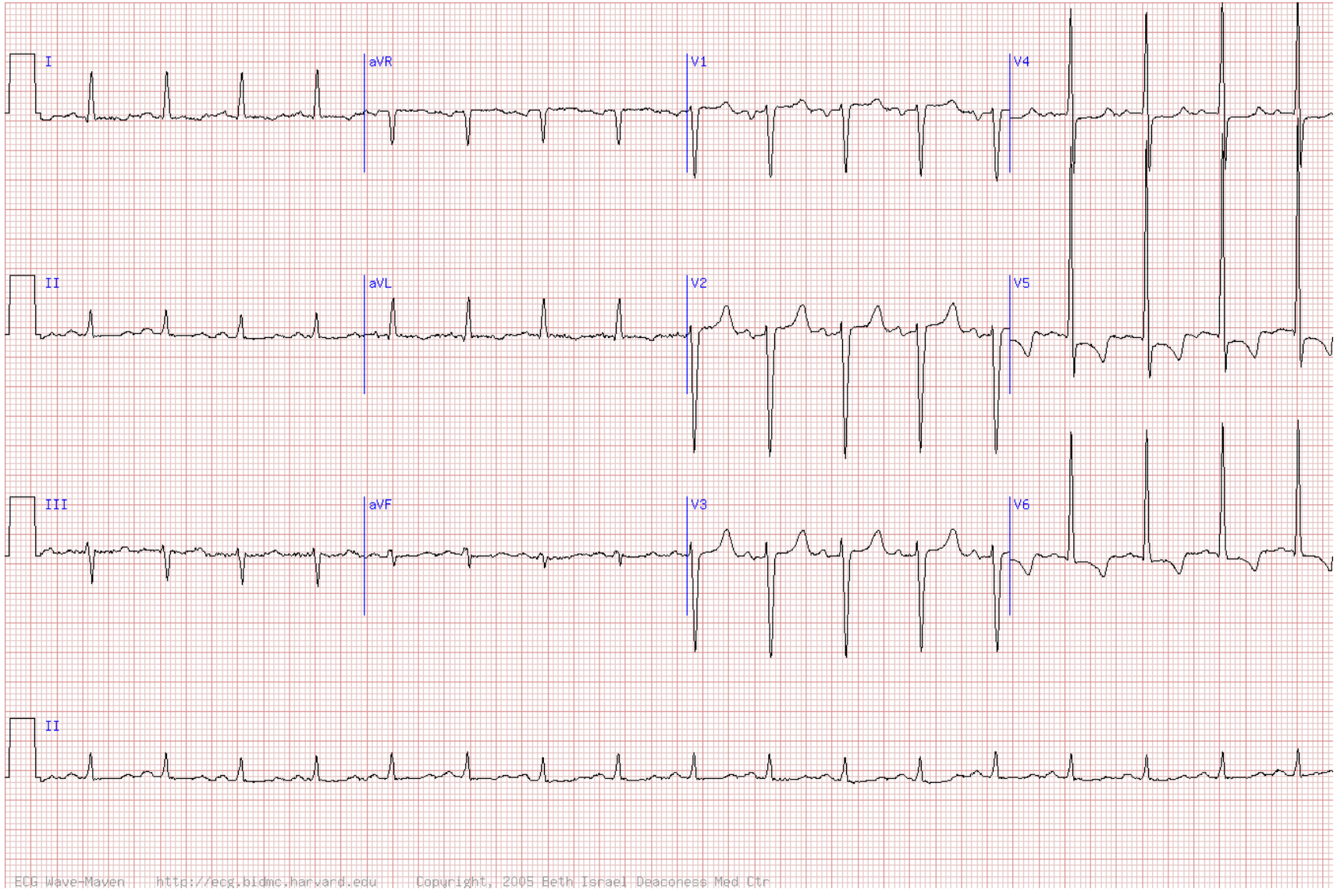
23 year old woman with palpitations



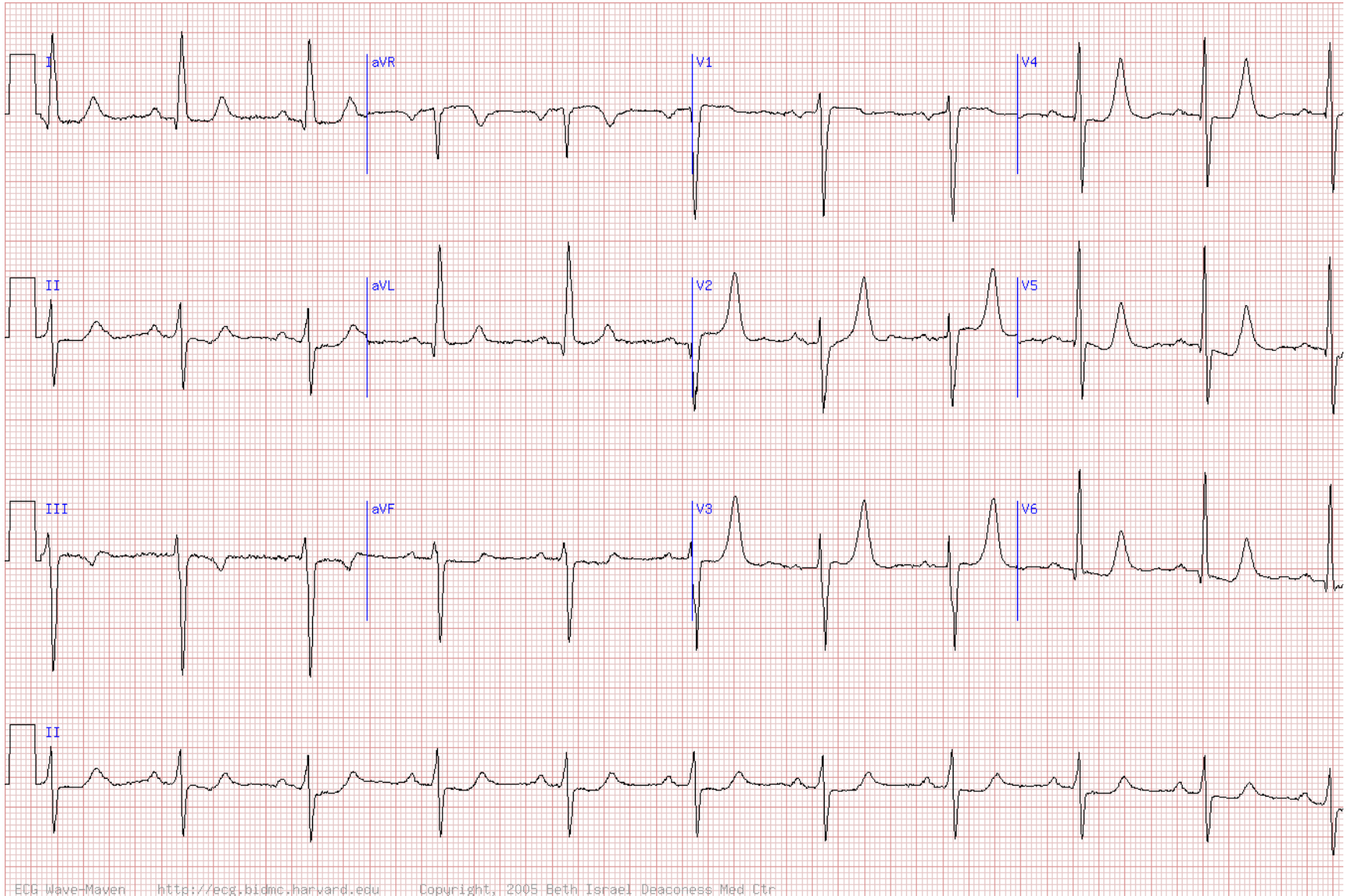
70 year old man with hypercholesterolemia



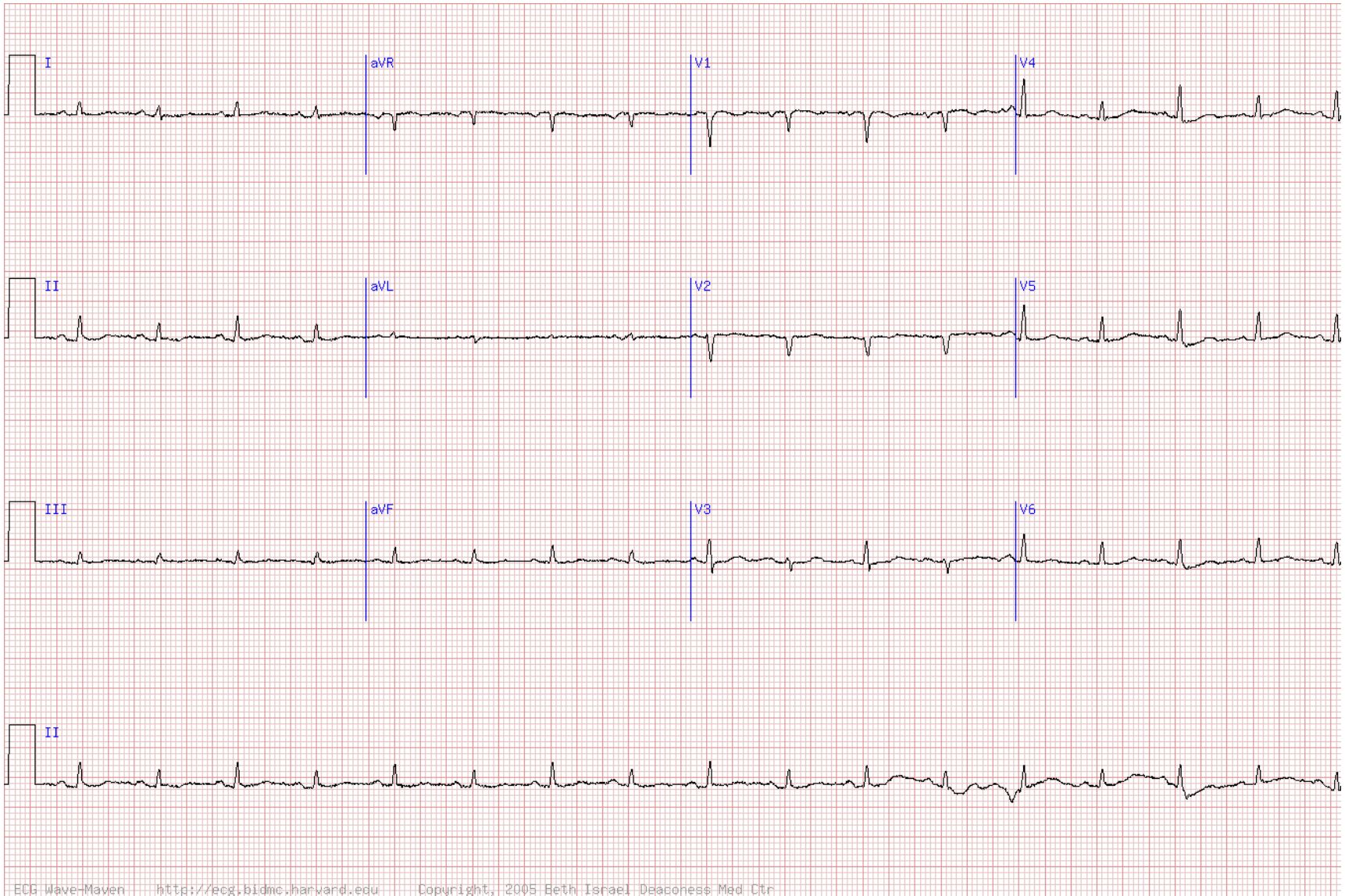
61 year old man with history of hypertension



77 year old woman with renal failure



62 year old man with increasing dyspnea



Thank you for your attention and do not forget to do the survey!