

Zakład Medycyny Rodzinnej
Uniwersytetu Medycznego
w Łodzi

Family Medicine for English language students of Medical University of Lodz

ECG

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Parts of an ECG

- The standard ECG has **12 leads**: six of them are considered „limb leads” because they are placed on the arms and/or legs of the individual. The other six leads are considered „precordial leads” because they are placed on the torso (precordium).
- The **six limb leads** are called lead I, II, III, aVL, aVR and aVF. The letter “a” stands for “augmented,” as these leads are calculated as a combination of leads I, II and III.
- The **six precordial leads** are called leads V1, V2, V3, V4, V5 and V6.

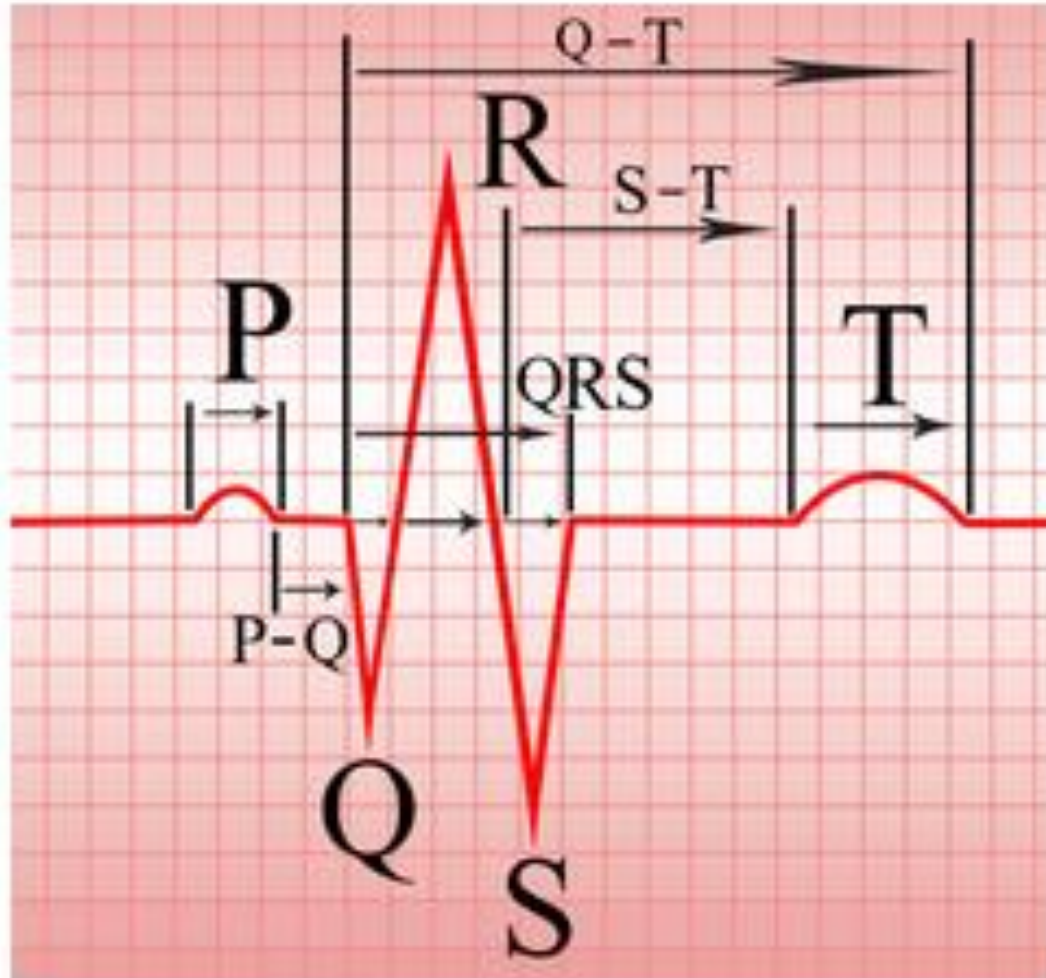
The Normal ECG

- A normal ECG contains waves, intervals, segments and one complex, as defined below.
- **Wave:** A positive or negative deflection from baseline that indicates a specific electrical event. The waves on an ECG include the P wave, Q wave, R wave, S wave, T wave and U wave.
- **Interval:** The time between two specific ECG events. The intervals commonly measured on an ECG include the PR interval, QRS interval (also called QRS duration), QT interval and RR interval.

The Normal ECG

- **Segment:** The length between two specific points on an ECG that are supposed to be at the baseline amplitude (not negative or positive). The segments on an ECG include the PR segment, ST segment and TP segment.
- **Complex:** The combination of multiple waves grouped together. The only main complex on an ECG is the QRS complex.
- **Point:** There is only one point on an ECG termed the J point, which is where the QRS complex ends and the ST segment begins.

The Normal ECG

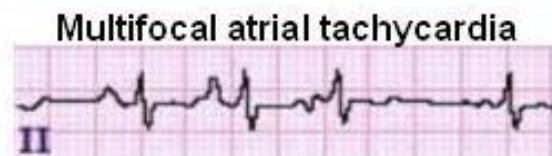
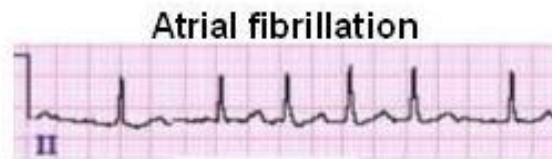


Determining Rate

- 50 mm/s – 600 divided by the number of „large boxes”
- 25 mm/s – 300 divided by the number of „large boxes”

Determining Rhythm

- If there is a P wave before every QRS complex, and it has a sinus morphology, then **normal sinus rhythm** (NSR) is said to be present. A sinus morphology is an upright P wave in lead II and biphasic (up and down) P wave in lead V1.
- Examples of rhythms **other than sinus rhythm**: atrial fibrillation, atrial flutter and multifocal atrial tachycardia.

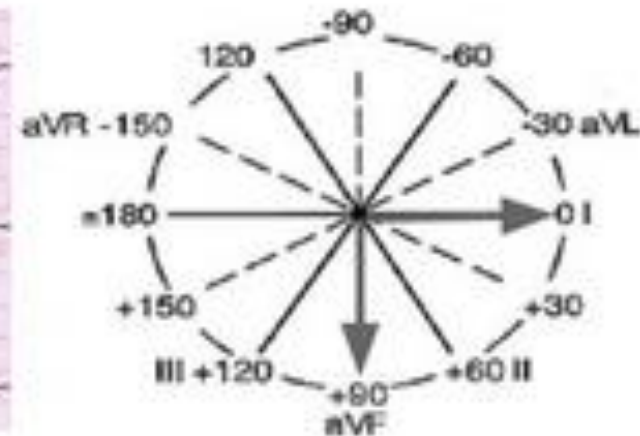


Determining Axis

- The axis of the ECG is the major direction of the overall electrical activity of the heart. It can be **normal, leftward** (left axis deviation, or LAD), **rightward** (right axis deviation, or RAD) or **indeterminate** (northwest axis). The QRS axis is the most important to determine.

Normal QRS Axis

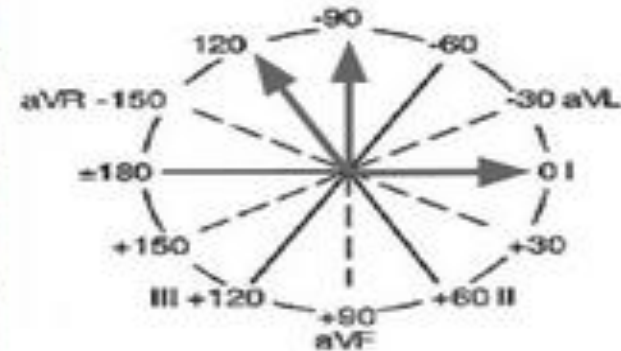
- If the QRS complex is upright (positive) in both lead I and lead aVF, then the axis is normal.



Normal QRS Axis: Positive in Lead I and aVF

Left Axis Deviation

- LAD

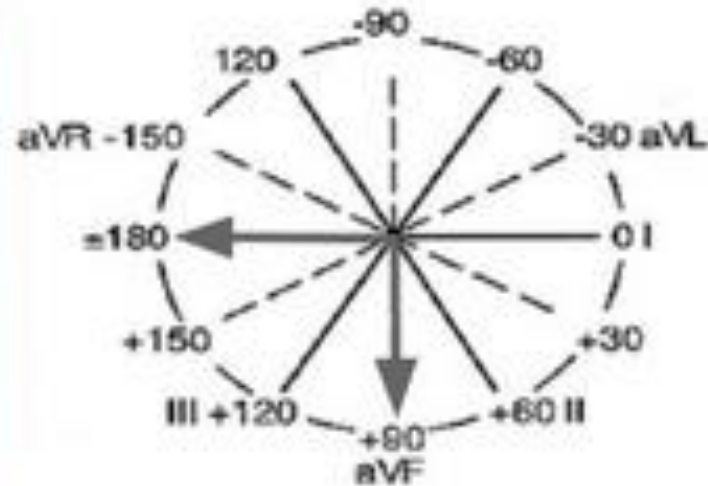


Left Axis Deviation of the QRS Axis:
Positive in Lead I, negative in lead aVF and lead II

- Normal variant – QRS: I – up, II – up, III - down

Right Axis Deviation

- If the QRS is predominantly negative in lead I and positive in lead aVF, then the axis is rightward (right axis deviation).



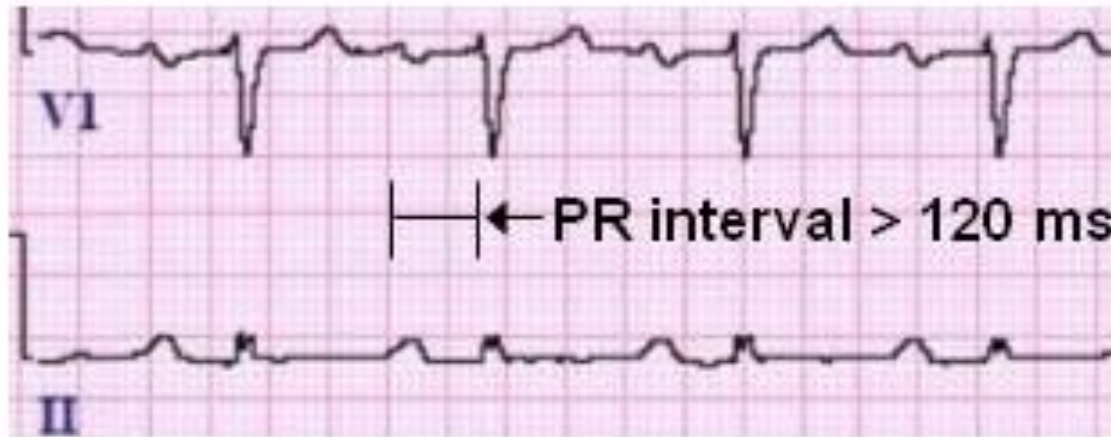
Right Axis Deviation of the QRS Axis:
Negative in Lead I and positive in lead aVF

P Wave

- Indicates atrial depolarization. The P wave occurs when the sinus node — also known as the sinoatrial node, or SA node — creates an action potential that depolarizes the atria.

PR Interval

- The time from the beginning of the P wave, indicating atrial depolarization, to the beginning of the QRS complex, representing ventricular depolarization.
- The normal PR interval is 0.12 to 0.20 seconds, or 120 to 200 milliseconds.

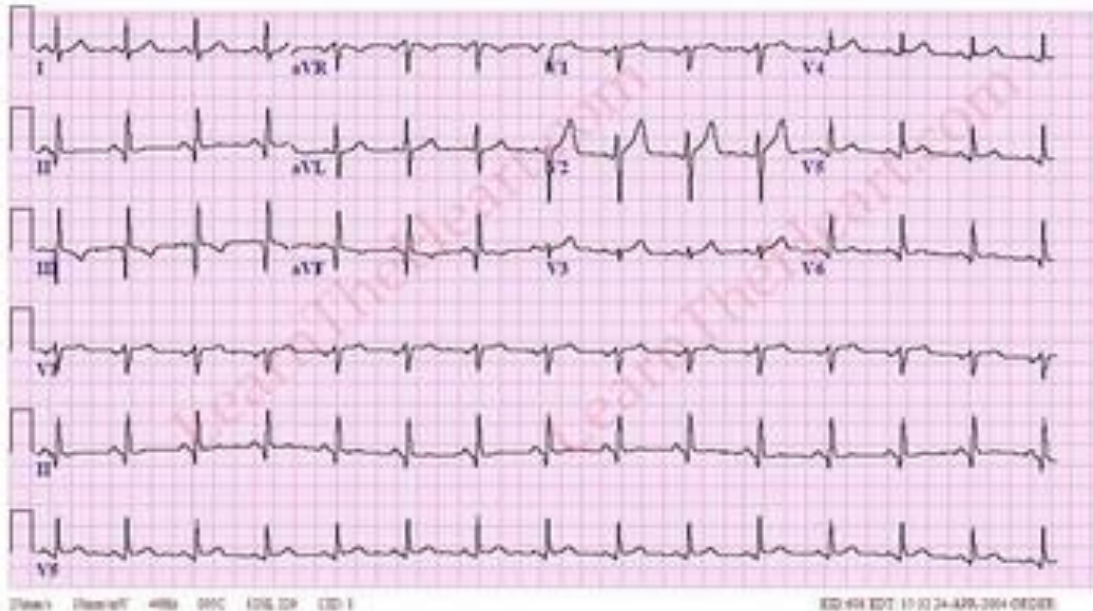


PR Segment

- The PR segment is the portion of the ECG from the end of the P wave to the beginning of the QRS complex.

Q Wave

- The Q wave is the first downward deflection after the P wave and the first element in the QRS complex. When the first deflection of the QRS complex is upright, then no Q wave is present.
- Abnormalities of the Q waves are mostly indicative of myocardial infarction.



R Wave

- The R wave is the first upward deflection after the P wave and part of the QRS complex.
- Throughout the precordial leads (V1-V6), the R wave becomes larger — to the point that the R wave is larger than the S wave in lead V4. The S wave then becomes quite small in lead V6; this is called “**normal R wave progression**.” When the R wave remains small in leads V3-V4 — that is, smaller than the S wave — the term “**poor R wave progression**” is used.

R Wave

Normal R wave progression



Poor R wave progression



S Wave

- The S wave is the first downward deflection of the QRS complex that occurs after the R wave. However, a S wave may not be present in all ECG leads in a given patient.
- In the normal ECG, there is a large S wave in V1 that progressively becomes smaller, to the point that almost no S wave is present in V6.

QRS Complex

- A combination of the Q wave, R wave and S wave, the “QRS complex” represents **ventricular depolarization**.
- The normal duration (interval) of the QRS complex is between 0.08 and 0.10 seconds.
- The QRS duration will lengthen when electrical activity takes a long time to travel throughout the ventricular myocardium.
- A widened QRS duration occurs in the setting of a right bundle branch block, left bundle branch block, non-specific intraventricular conduction delay and during ventricular arrhythmias such as ventricular tachycardia

T Wave

- The T wave occurs after the QRS complex and is a result of **ventricular repolarization**. T waves should be upright in most leads; the exceptions are aVR and V1.
- Many abnormal T wave patterns exist: these include hyperkalemia, left ventricular hypertrophy with repolarization abnormalities, pericarditis (stage III), arrhythmogenic right ventricular dysplasia (ARVD) and hyperacute T waves during myocardial infarction.

QT Interval

- The QT interval is the time from the beginning of the QRS complex, **representing ventricular depolarization**, to the end of the T wave, resulting from **ventricular repolarization**.
- The normal QT interval is controversial, and multiple normal durations have been reported. In general, the normal QT interval is below 400 to 440 milliseconds.
- Due to the effects of heart rate, the **corrected QT interval** (QTc) is frequently used. The QTc is considered prolonged if greater than 450 ms in males and 470 ms in females. It is calculated using Bezett's formula, described below.

Bezett's Formula

$$QTc = \frac{QT \text{ interval}}{\sqrt{RR}}$$

QTc = Corrected QT interval

QT interval = Q wave to end of T wave

RR = Time from two consecutive R waves

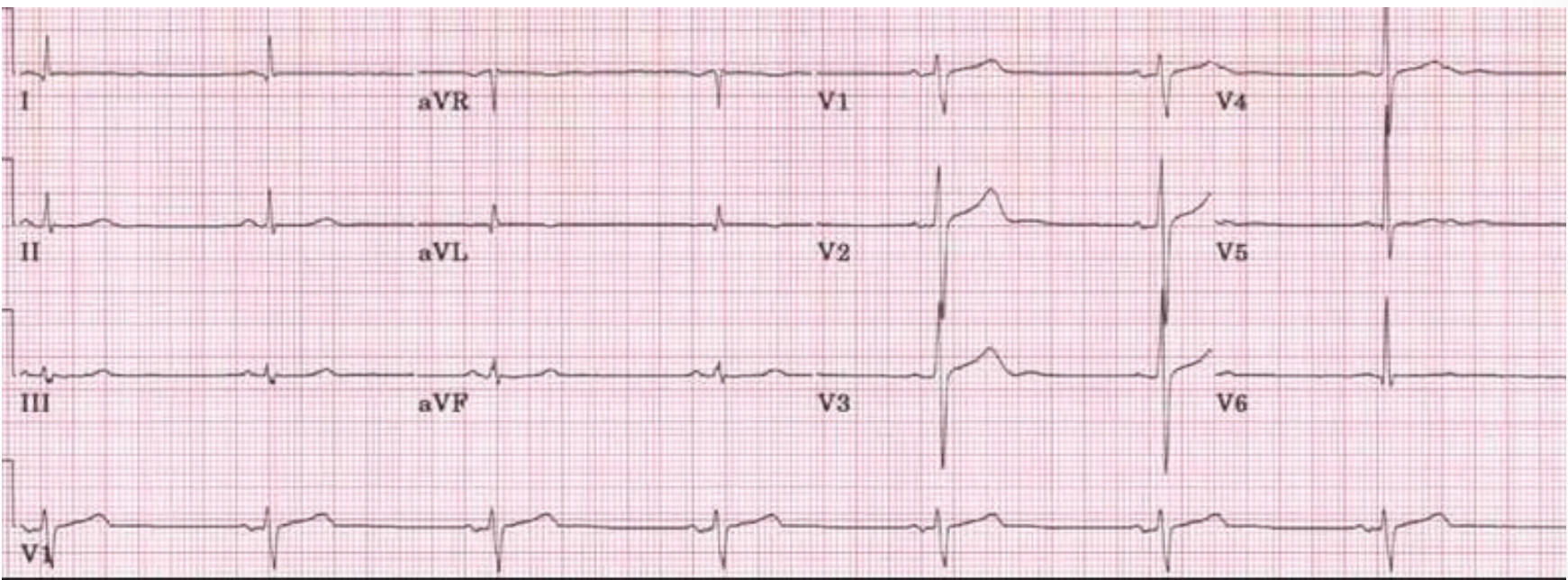
ST Segment

- The ST segment is the portion of the ECG from the end of the QRS complex to the beginning of the T wave. The ST segment normally remains isoelectric, thus ST segment depression or ST segment elevation can indicate cardiac pathology.
- The ST segment is scrutinized on the ECG for the detection of myocardial ischemia.

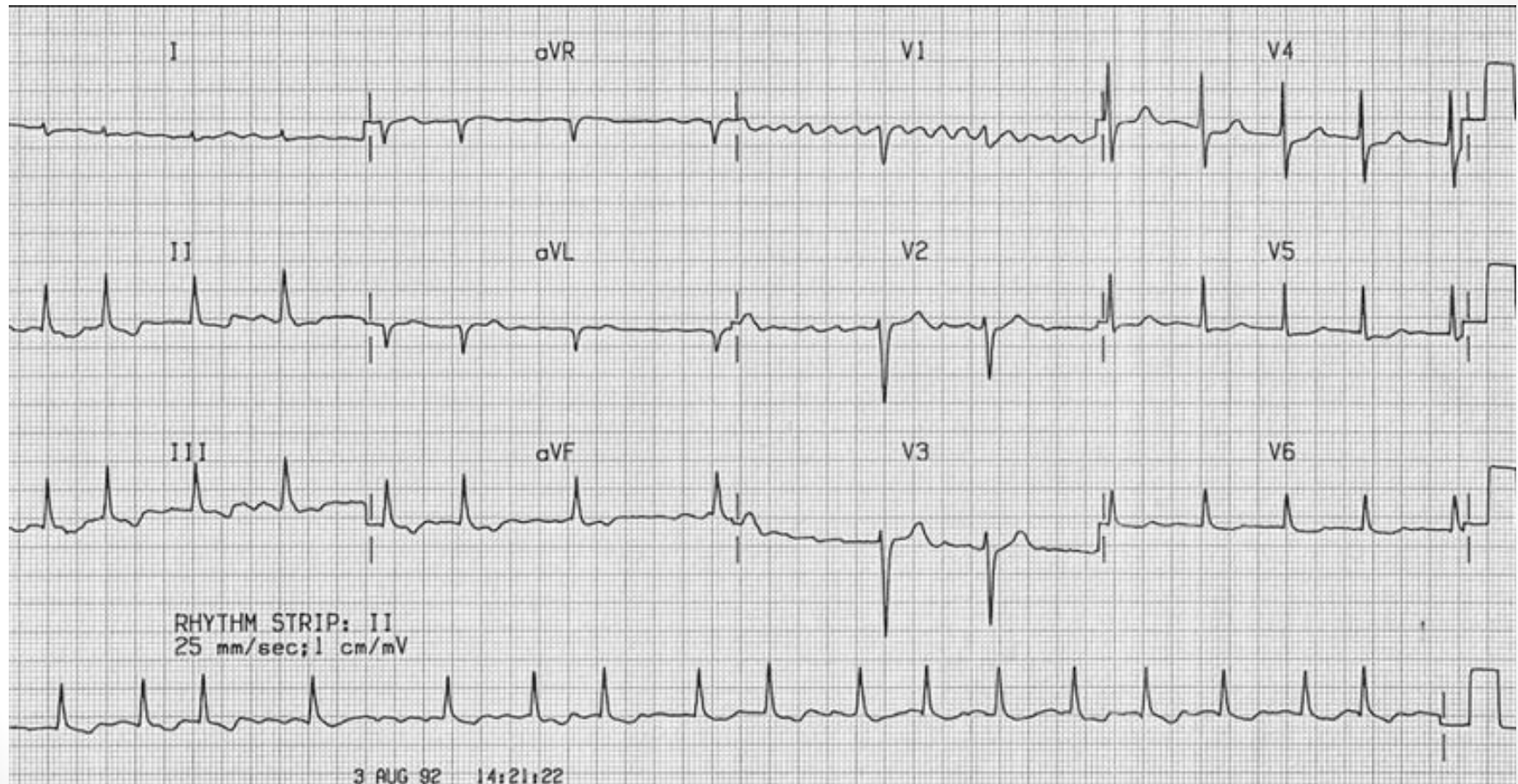
TP Segment

- The TP segment is the portion of the ECG from the end of the T wave to the beginning of the P wave. This segment should always be at baseline and **is used as a reference to determine if the ST segment is elevated or depressed**, as there are no specific disease conditions that elevate or depress the TP segment.

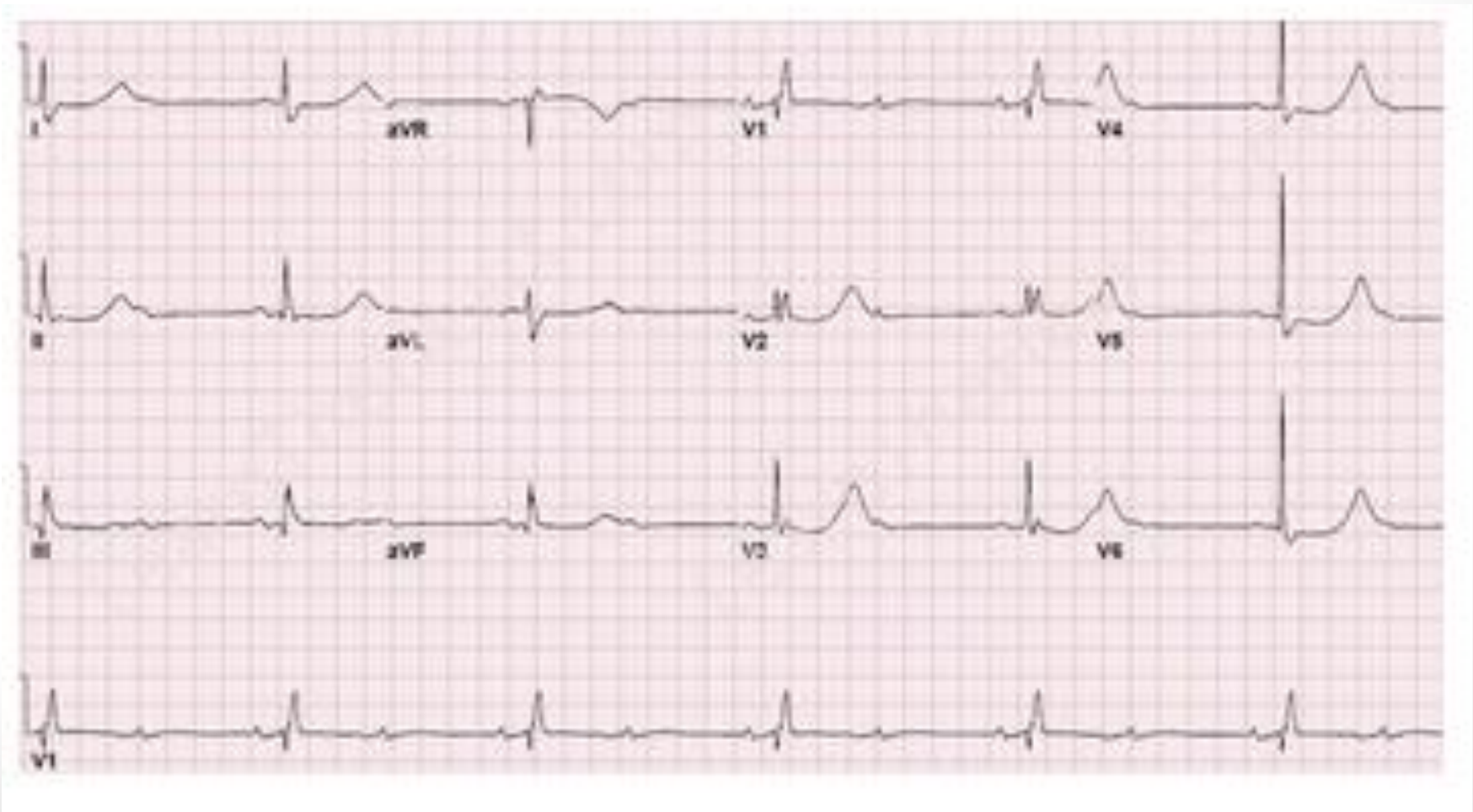
Example 1



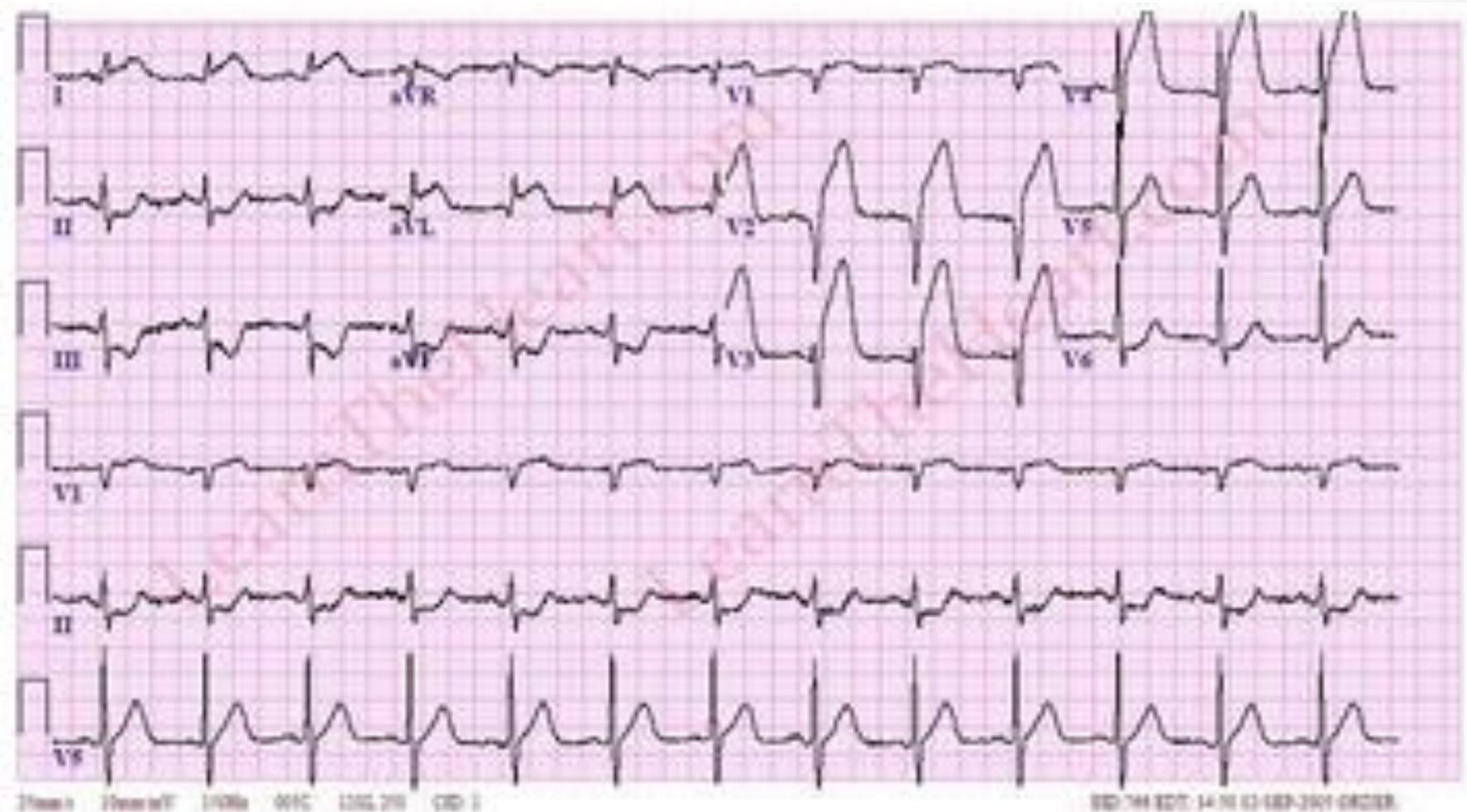
Example 2



Example 3



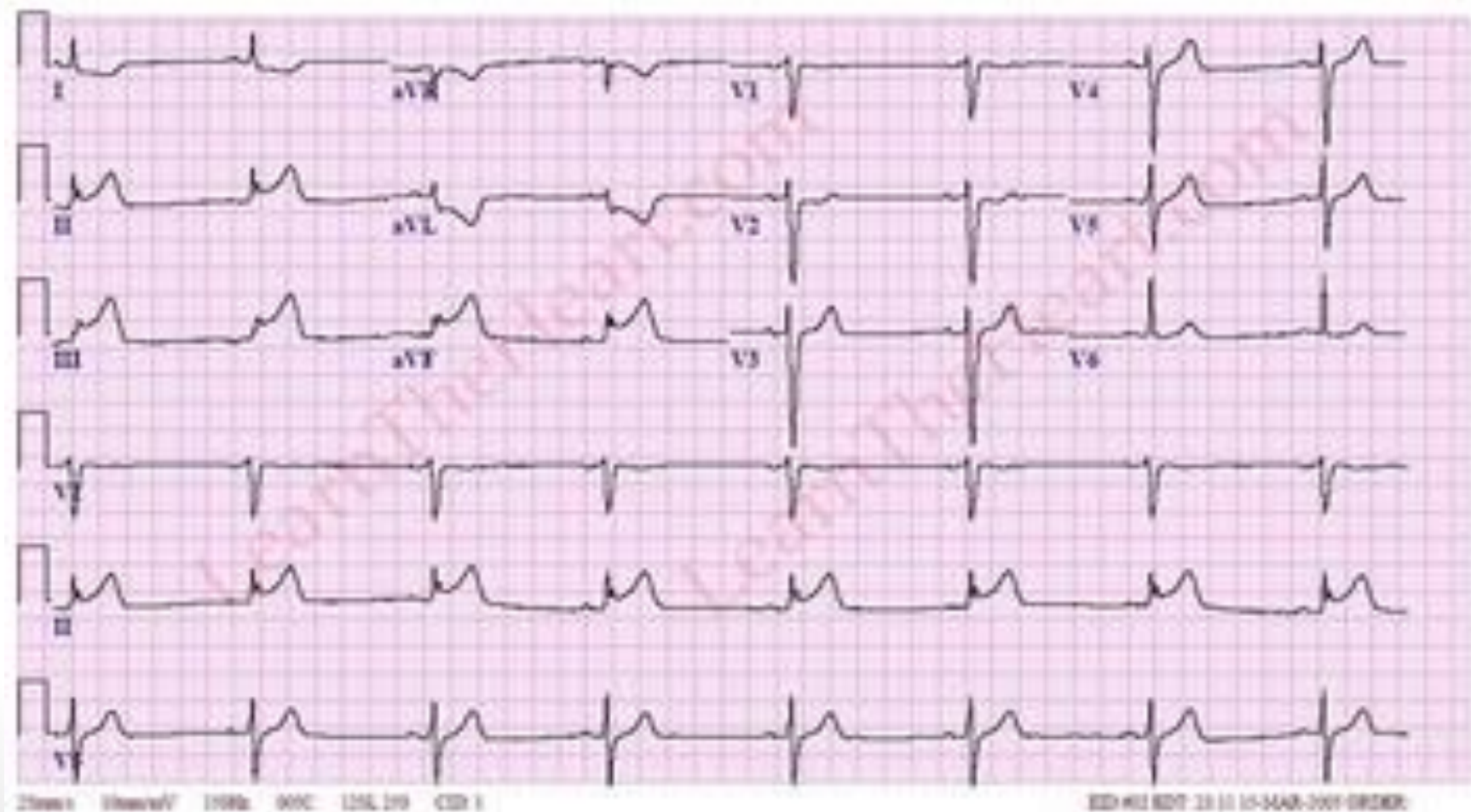
Example 4



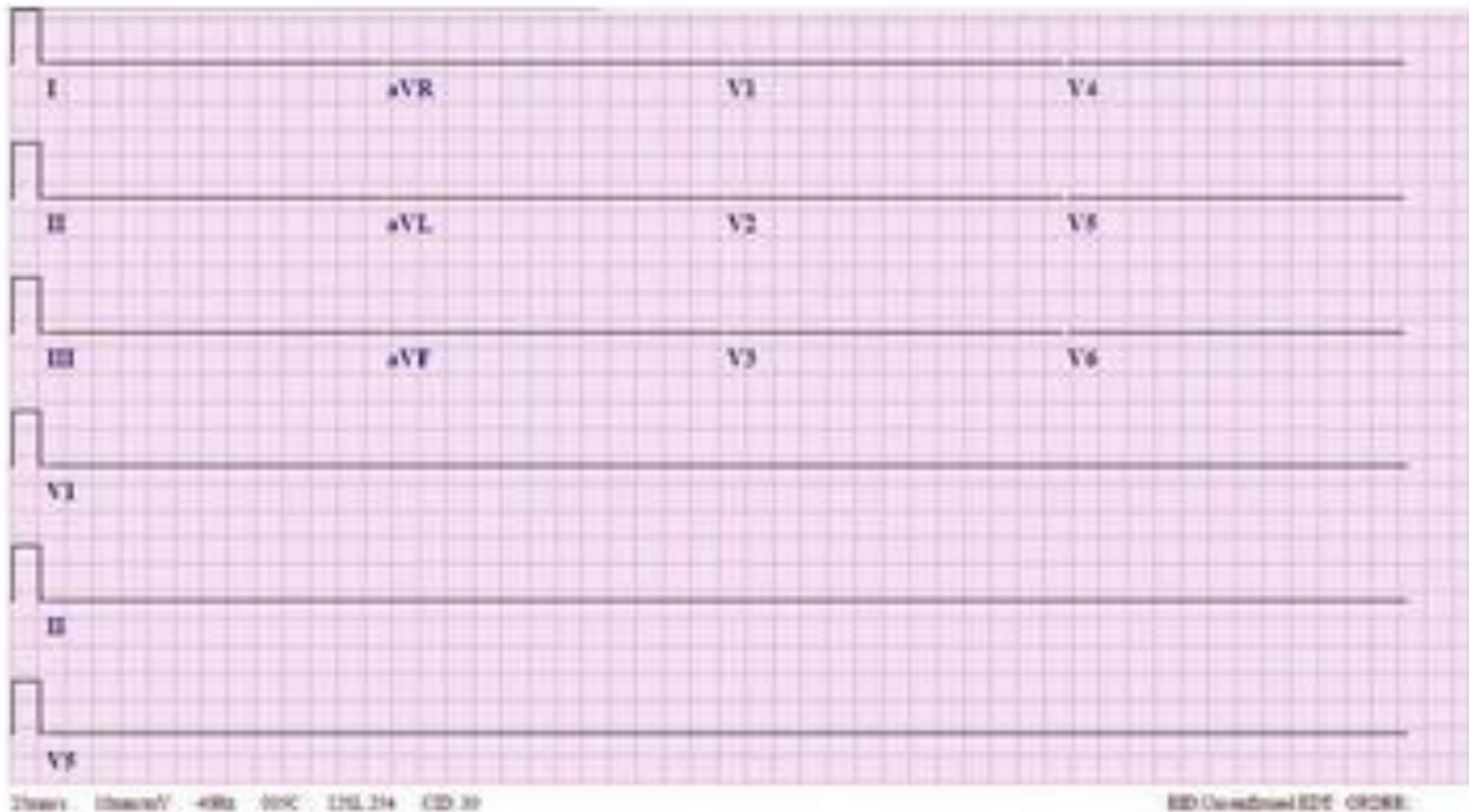
STEMI

- According to the ACC/AHA guidelines for STEMI, there must be “new ST elevation at the J point in at least two contiguous leads of ≥ 2 mm (0.2 mV) in men or 1.5 mm (0.15 mV) in women in leads V2-V3 and/or of ≥ 1 mm (0.1 mV) in other contiguous chest leads or the limb leads.”

Example 5



Example 6



- Example 1 – sinus bradycardia
- Example 2 – AF
- Example 3 – 2nd degree AV block 2:1
- Example 4 – anterior wall STEMI
- Example 5 – inferior wall STEMI + sinus bradycardia
- Example 6 - asystole