12-Lead ECG Notes

Bipolar Limb Leads – Have both a distinctive positive and negative pole.
- Lead I – LA (positive) → RA (negative)
- Lead II – LL (positive) → RA (negative)
- Lead III – LL (positive) → LA (negative)

Unipolar Limb Leads – Have only a distinct positive pole.
- Lead aVR – RA (positive) → Central Terminal (negative)
- Lead aVL – LA (positive) → Central Terminal (negative)
- Lead aVF – LL (positive) → Central Terminal (negative)

Precordial (Unipolar) Leads – Have only a positive pole.
- Lead V1 (positive) → 4th ICS, just to the right of the sternum
- Lead V2 (positive) → 4th ICS, just to the left of the sternum
- Lead V3 (positive) → between V2 and V4
- Lead V4 (positive) → 5th ICS, mid-clavicular line
- Lead V5 (positive) → level with V4 on the anterior axillary line
- Lead V6 (positive) → level with V4 and V5 on the mid-axillary line
- Lead V8 (positive) → level with V4-V6 on the mid-scapular line
- Lead V9 (positive) → level with V4-V6 and V8, just to the left of the spine
- Lead V4R (positive) → 5th ICS, right mid-clavicular line

“View” Of Each Lead (Remember “I see all leads” – ISAL PR)
- Inferior Wall (Left Ventricle) → II, III, aVF
- Septal Wall (Left Ventricle) → V1, V2
- Anterior Wall (Left Ventricle) → V3, V4
- Lateral Wall (Left Ventricle) → V5, V6, I, aVL
- Posterior Wall (Left Ventricle) → V8, V9
- Right Ventricle → V4R

Indicative ECG Changes – ST-segment elevation is the most specific for acute MI. (Remember to measure ST-segment elevation or depression from the J-point to the isoelectric line. Also remember, the TP-segment is a better indicator of isoelectric than the PR-segment.)
- Ischemia → ST-depression (≥1 mm) and/or symmetric T-wave inversion in 2 or more anatomically contiguous leads.
- Injury (Acute) → ST elevation (≥1 mm) in 2 or more anatomically contiguous leads. (Elevation needs to be ≥2 mm in the septal leads [V1, V2].)
- Infarction (May be acute or old [age-indeterminate]) → Pathologic Q-waves any one lead. Q-waves are considered pathologic when they are greater and 40 ms in duration and/or have a depth ≥1/2 the height of the R-wave they precede. QS-waves are always considered pathologic Q-waves, unless they are present only in lead V1. QS-waves can be normal in Lead V1.
**12-Lead ECG Notes**

**Reciprocal Changes** – Confirms the presence of ST elevation. Look for ≥1mm ST depression in a reciprocal lead. Considered significant if present in one reciprocal lead.

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**Myocardial Circulation** (Remember PALS and RIP)

- **Left Coronary Artery**
  - Posterior Wall (Left Ventricle)
  - Anterior Wall (Left Ventricle)
  - Lateral Wall (Left Ventricle)
  - Septal Wall (Left Ventricle)
  - Left Bundle Branch
  - Right Bundle Branch
  - Both Fascicles of Left Bundle Branch

- **Right Coronary Artery**
  - Right Ventricle
  - Inferior Wall (Left Ventricle)
  - Posterior Wall (Left Ventricle)
  - AV Node (90% of the population)
  - Posterior Hemifascicle of LBB

***ECG evidence has only 50% sensitivity for a MI.***

***A 12-Lead ECG can never “rule out” an AMI!!!***

50% of Inferior Wall MI’s have an associated Posterior Wall and/or Right Ventricular Infarction! Run a 15 lead ECG on all patients with Inferior Wall MI or with non-diagnostic ECG’s.

**Axis and Hemiblocks**

- **Normal Axis** – Between 0° and 90°. Complexes will be predominantly positive in Lead I and predominantly positive in Lead aVF.
- **Left Axis Deviation** – Between 0° and -90°. Complexes will be predominantly positive in Lead I and predominantly negative in Lead aVF.
- **Right Axis Deviation** – Between 90° and 180°. Complexes will be predominantly negative in Lead I and predominantly positive in Lead aVF.
12-Lead ECG Notes

Anterior Hemifascicular Block – Pathologic left axis deviation. Left axis deviation is considered pathological when it is between -40° and -90°. This will produce a predominately negative complex in Lead II. (Positive in Lead I, Negative in Lead AVF, and Negative in Lead II.)

Posterior Hemifascicular Block – Right axis deviation indicates a posterior hemiblock only if the patient is an adult and there is no evidence of right atrial abnormality or right ventricular hypertrophy.

Bundle Branch Blocks

“Turn Signal” Theory → Must be used in Lead V1. The complex must be supraventricular in nature and must be ≥120 ms in duration. Confirm with the morphology in Lead I and Lead V6.

• Left Bundle Branch Block → Turn signal theory indicates “Left” and broad, monomorphic R-waves, with no Q waves in Lead I and Lead V6.

• Right Bundle Branch Block → Turn signal indicates “Right” and slurred S-waves in Lead I and Lead V6.

Bifascicular Block – Two of the three pathways to the ventricles are blocked. LBBB, RBBB and anterior hemifascicular block, or RBBB and posterior hemifascicular block. (Bifascicular block is considered a severe degree of heart block the same as 2nd degree type II or 3rd degree heart block.)

Criteria Suggestive of Ventricular Tachycardia when presented with a stable wide complex tachycardia of unknown origin. If you meet any of the following criteria treat for Ventricular Tachycardia. If unstable, treatment is the same → DC Cardioversion!

• Extreme right axis deviation and predominately positive complex in Lead V1.

• Morphology in V1. If V1 is upright → R is taller than R¹, single upright peak, single upright peak with a slur on the right side. If V1 is negative → R-wave with duration greater than 40 ms before the S-wave, slurring or notching to the initial downstroke (S or QS-wave).

• Morphology in V6. Any negative deflection. (QS wave, predominately negative complex with a small R-wave, Q-wave of greater than 40 ms in a predominately positive complex.)
12-LEAD ECG NOTES

- **Right axis deviation and a predominantly negative complex in Lead V1.**
- **Concordance of the V-Leads.** All V-Leads are predominantly positive or all V-Leads are predominantly negative.
- **RS interval in any V-Lead is >100 ms.** RS-interval is measured from the beginning of the QRS complex to the point of the S-wave.
- **QRS duration:** >140 ms in a predominantly positive complex in Lead V1 or >160 ms in a predominantly negative complex in Lead V1.

**OTHER VENTRICULAR TACHYCARDIA CLUES**
- V-Tach, unless drug induced is usually *very regular.*
- **AV dissociation** in a wide complex tachycardia is diagnostic for V-Tach.
- **Fusion** and capture beats indicate V-Tach.
- Two questions: “Have you had a MI before?” and “Did you have tachycardia after the MI?” If the answer to both questions is yes the odds favor V-Tach as the current arrhythmia.

**ATRIAL ABNORMALITIES**
- **Right Atrial Abnormality** \(\rightarrow\) Tall, pointed P-wave in the inferior leads (II, III, aVF) that is greater than 2.5 mm in amplitude.
- **Left Atrial Abnormality** \(\rightarrow\) Wide (>120 ms) P-wave with a notched or “m” shaped appearance in lead II or a broad, terminal, negative deflection of the P-wave in Lead V1 measuring 1 mm deep and 1 mm wide.

**VENTRICULAR HYPERTROPHY**
- **Right Ventricular Hypertrophy** \(\rightarrow\) Voltage criteria – R-wave in V1 ≥ 7 mm. You also need one of the following to confirm RVH: Right atrial abnormality or strain pattern.
  Strain pattern is asymmetrical downsloping ST segment depression, often into an asymmetrically inverted T-wave. In RVH, strain is usually seen in the inferior leads (II, III and aVF) and/or the right precordial leads (V1-V3).
- **Left Ventricular Hypertrophy** \(\rightarrow\) Voltage criteria – “Rule of 35.” Deepest S-wave in V1 or V2 plus the tallest R-wave in V5 or V6. If this number is greater than 35 and the patient is older than 35 years of age, voltage criteria is met. (R-wave in Lead aVL of >11 mm will also meet voltage criteria.) Once a voltage criterion is met, you also need one of the following to confirm LVH: Left atrial abnormality or strain pattern.
  Strain pattern is asymmetrical downsloping ST segment depression, often into an asymmetrically inverted T-wave. In LVH, strain is usually seen in the inferior (II, III, aVF) and/or lateral leads (V5 and V6).

**INfarCT IMPOSTERS** – The following five conditions will mimic the changes seen in an acute MI. Cannot use the normal criteria to identify a myocardial infarction!
12-Lead ECG Notes

- **Left Bundle Branch Block** → Causes ST-segment elevation and QS-complexes in the negatively deflected leads, usually V1, V2, and V3. LBBB is usually considered a “non-diagnostic” ECG, however if it can be confirmed that a LBBB is new and occurs in the setting of signs and symptoms of an MI it meets the diagnostic criteria.


- **Left Ventricular Hypertrophy** → Causes ST-segment elevation in the negatively deflected leads, usually V1, V2, and V3.

- **Pericarditis** → Causes diffuse ST-segment elevation, notching of the J-point, and PR-segment depression. History and physical exam is the key to recognizing pericarditis.

- **Early Repolarization** → Causes ST-segment elevation, notching of the J-point and tall T-waves, particularly in the anterolateral leads. Occurs most often in young-adult black males.

12-Lead Analysis

- **Analyze the rhythm.** If it is a wide complex tachycardia refer to the criteria for V-Tach. Identify and convert V-Tach. If it is not a WCT or if the WCT is not V-Tach, continue.

- **Identify Rhythm.**

- **Determine axis and hemifascicular blocks**, if present. (Remember, you must rule out right atrial abnormality and right ventricular hypertrophy before you can identify a posterior hemifascicular block.)

- **Determine the QRS width.** If ≥120 ms determine the bundle branch block using the “turn signal” theory in Lead V1. If it is a LBBB, it is non-diagnostic. Treat the patient based on history and physical and accommodate acquisition of an old ECG. If the QRS is narrow, or if it is a RBBB, continue.

- Use “I See All Leads” pneumonic to systematically search for acute indicative changes.
  - ST-segment elevation is the best indicator of acute injury.
  - ST-segment depression may be reciprocal changes caused by an acute MI or the acute changes of ischemia. If there is an MI present and the depression is in reciprocal leads it is reciprocal changes, otherwise they are caused by ischemia.
  - Don’t forget about the infarct imposters.

- **Acquire 15-Lead ECG** if an Inferior MI is present or if no acute changes are noted.

- **Begin clinical interventions** as indicated by the patient’s condition.

- **Triage the patient** per ACLS criteria and perform thrombolytic screening for those in the ST-elevation AMI category. Notify the receiving facility as soon as possible.

- Look for chamber enlargement and consider the hemodynamics that caused it.