The Fundamentals of 12 Lead EKG

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Reviewing the Cardiac Conductive System

- SA Node
- Intranodal Pathways
- AV Junction
- AV Fibers
- Bundle of His
- Septum
- Bundle Branches
- Purkinje System

ECG Recording

J-Point

- The point marking the end of the QRS complex and the beginning of the following part that merges into the T wave in an electrocardiogram
- Generally, where the waveform begins to move more horizontal than vertical
**J Point Examples**

![J Point Examples](image1.png)

**More J-Point Examples**

![More J-Point Examples](image2.png)

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**ECG Leads**

- ECG Leads
  - Bipolar
    - Leads I, II, and III
  - Unipolar
    - Leads aVR, aVL, and aVF
  - Precordial
    - $V_1$, $V_2$, $V_3$, $V_4$, $V_5$, $V_6$

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**Planes**

![Planes](image3.png)
Frontal Plane

• Leads I, II, III, aVR, aVL, and aVF
• Records electrical activity of the heart in the frontal plane of the body through the extremity leads
Horizontal Plane Leads

• Leads V1, V2, V3, V4, V5, and V6
• Looks at the heart on a horizontal plane

Bipolar Leads

• Bipolar Limb Leads
  – Lead I
  – Lead II
  – Lead III
  – Einthoven’s Triangle

Unipolar Leads

• Unipolar or Augmented Limb Leads
  – Lead aVR
  – Lead aVL
  – Lead aVF
Precordial Leads

- Precordial Leads
  - Lead $V_1$
  - Lead $V_2$
  - Lead $V_3$
  - Lead $V_4$
  - Lead $V_5$
  - Lead $V_6$

Electrical Axis of the Heart

- **Lead Axis**: An imaginary line from the positive electrode to the negative electrode for each lead, depicted by an arrow (vector)
- **Mean QRS Axis**: The axis of the heart as a whole; the aggregate of all the electrical vectors in the heart
- Measured in degrees
- Most 12 leads determine axis of $P$, QRS, and $T$ waves

Mean QRS Axis

Electrical Axis of the Heart

- To determine exact axis manually, the height of the QRS complexes can be measured and plotted on a triaxial reference system.
  - Is little use in the pre-hospital setting
- A more practical system can be used by looking at Leads I, II, and III...
Rapid Axis Determination Utilizing Leads I, II, and III

Causes of Left Axis Deviation
• Left anterior block
• Inferior MI
• Artificial cardiac pacing
• Emphysema
• Hyperkalemia
• WPW-right sided accessory pathway

Causes of Right Axis Deviation
• Normal finding in children and tall slim adults
• Right ventricular hypertrophy
• Chronic lung diseases
• WPW-left sided accessory pathway
• Atrial or ventricular septal defect

Causes of Indeterminate Axis Deviation
• Emphysema
• Hyperkalemia
• Transposed lead placement
• Artificial pacing
• V-Tach
• Inferior or lateral MI
EKG Deflections

An equihasis deflection (equally positive and negative) is produced when the lead axis is perpendicular to the heart's mean QRS axis.

The deepest negative deflection is created when the lead axis is parallel to the mean QRS axis and current is flowing away from that lead's positive electrode.

The tallest positive deflection is created when the lead axis is parallel to the mean QRS axis and current is flowing toward that lead's positive electrode.

Wave Definitions

- R wave
- Q wave
- S wave
- J point
- QT interval

The Normal 12-Lead (1 of 2)

- The Normal 12-Lead
  - Views the same series of electrical events from 12 perspectives.

The Normal 12-Lead (2 of 2)
Another Standard Layout

Interpretation of 12 Lead EKGs

- 5 + 3 Approach
- Five basic steps
  - Rate
  - Rhythm
  - P-wave
  - PR Interval
  - QRS complex

Interpretation of 12 Lead EKGs

- +3
  - ST Depression
    - Present?
    - In which leads?
    - Reciprocal?
  - ST Elevation
    - Present?
    - In which leads?
    - Is there reciprocal ST depression present?
  - Q Waves
    - Present?
    - In which leads?
    - Are they pathologic or nonpathologic?

Multi-Lead Heart Assessment
### 12 Lead ECG Basics

#### Limb Leads

<table>
<thead>
<tr>
<th>Lead</th>
<th>P wave</th>
<th>QRS</th>
<th>T wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>upright</td>
<td>upright</td>
<td>upright</td>
</tr>
<tr>
<td>II</td>
<td>upright</td>
<td>upright</td>
<td>upright</td>
</tr>
<tr>
<td>III</td>
<td>upright</td>
<td>upright</td>
<td>upright</td>
</tr>
</tbody>
</table>

#### Augmented Limb Leads

<table>
<thead>
<tr>
<th>Lead</th>
<th>P wave</th>
<th>QRS</th>
<th>T wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>aVR</td>
<td>negative</td>
<td>negative</td>
<td>negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/upright</td>
<td></td>
</tr>
<tr>
<td>aVL</td>
<td>upright</td>
<td>upright</td>
<td>upright</td>
</tr>
<tr>
<td>aVF</td>
<td>upright</td>
<td>upright</td>
<td>upright</td>
</tr>
</tbody>
</table>

### 12 Lead ECG Basics

#### Chest Leads

<table>
<thead>
<tr>
<th>Lead</th>
<th>P wave</th>
<th>QRS</th>
<th>T wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>upright/biphasic</td>
<td>small R wave / QS</td>
<td>upright</td>
</tr>
<tr>
<td>V2</td>
<td>upright/biphasic</td>
<td>small R wave / QS</td>
<td>upright</td>
</tr>
<tr>
<td>V3</td>
<td>upright</td>
<td>equiphaseic QRS - upright</td>
<td>upright</td>
</tr>
</tbody>
</table>

### ST Elevation

- ST elevation of one millimeter or more, in at least two anatomically contiguous leads is considered presumptive evidence of an AMI
- Lateral Leads: I, aVL, V5, and V6
- Inferior Leads II, III, and aVF
- Septal Leads V1 and V2
- Anterior Leads V3 and V4
Leads and Artery Correlation

- Leads I, aVL, V5, and V6
  - Circumflex artery
  - Left anterior descending artery (LAD)
- Leads II, III, and aVF
  - Right coronary artery (RAC)
- Leads V1 and V2
  - Left anterior descending artery (LAD)
- Leads V5 and V6
  - Circumflex artery
  - Left anterior descending artery (LAD)

Pathologic Q Waves

- Also referred to as “significant” Q waves
- Defined as a width greater than or equal to 1 small box (0.04msec) or a depth greater than 1/3 of the R wave in the same lead
- Indicates irreversible tissue damage

Physiologic Q Waves

- AKA: Non-pathologic Q Waves
- Less than 0.04msec (one small box)
- Considered “Normal”
Acute Coronary Syndromes

Definition:
• Sudden ischemic disorders of the heart
• Includes unstable angina and acute myocardial infarction
• Represents a continuum of a similar disease process

Acute Coronary Syndromes

ACS refers to 3 levels of progressing cardiac disease findings:
• Myocardial Ischemia:
• Myocardial Injury:
• Myocardial Infarction

Myocardial Ischemia

• Lack of oxygen normally causing abnormalities in repolarization
• Can cause depression of the ST segment and inversion of the T wave
• If corrected, permanent damage can be avoided

Myocardial Injury

• Injury to the myocardium, typically following myocardial ischemia that results from loss of blood and oxygen supply to the tissue.
• The injured area tends to be partially or totally depolarized
• Sometimes causes ST elevation
Myocardial Infarction

- Death of the heart muscle
- Due to lack of blood and oxygen
- Location of the MI affects corresponding lead changes
- Can cause ST elevation

Acute Coronary Syndromes

- All have sudden ischemia
- Cannot be differentiated in the first hours of episode
- All have the same initiating events
  - Plaque Rupture
  - Thrombus Formation
  - Vasoconstriction

Risk Factors for ACS

- Diabetes
- Smoking
- Hypertension
- Age
- Hyperlipidemia

- Family history of CAD
- Obesity
- Stress
- Sedentary
- Non-estrogenized females

Atypical Presentations of ACS

- Pain that is sharp or intermittent
- Pain that is in the teeth, neck, shoulder, arm, or abdomen
- Mostly affects females, diabetics, and the elderly
Anginal Equivalents

• Dyspnea
• Palpitations
• Syncope or near syncope
• Generalized weakness with no history of a GI bleed or recent fever
• DKA
• May be the only signs/symptoms of ACS

Recognizing ACS

Story
+ Risk Factors
+ EKG
= Treatment

STEMI and Non-STEMI

• STEMI: ST elevation MI
• Non-STEMI: non ST elevation MI

Disease Findings

• Ischemia
  – ST segment depression with or without T wave inversion
• Injury
  – ST elevation >1mm in 2 congruent leads
    • With or without loss of R wave
    • >2mm in septal leads (V1, V2)
• Infarction
  – Pathological Q waves
    • >.04 sec wide or 1/3 of R, with ST elevation
    – STEMI
    – Non-STEMI
Ischemia, Injury, Infarct

Evolution of STEMI

Localization of an AMI

<table>
<thead>
<tr>
<th>Location of Myocardial Ischemia/Infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td>Leads</td>
</tr>
<tr>
<td>Anterior</td>
</tr>
<tr>
<td>Anterolateral</td>
</tr>
<tr>
<td>Lateral</td>
</tr>
<tr>
<td>High lateral</td>
</tr>
<tr>
<td>Inferior</td>
</tr>
<tr>
<td>Inferolateral</td>
</tr>
<tr>
<td>True posterior</td>
</tr>
</tbody>
</table>
Reciprocal Changes

II, III, aVF
I, aVL, V-Leads

• ST elevation may show as ST Depression in reciprocal leads and vice-versa
• Not necessary to presume infarction
• Strong confirming evidence when present

Region of ST Elevation
Region of ST Depression
Anterior (V1-V4)
Inferior (true posterior)
Inferior (II, III, aVF)
Anterior (V1-V3 or aVL)
Lateral (I, aVL, V5, V6)
Inferior (II, III, aVF)
True Posterior
Anterior (V1-V-3)

3 Subsets of 12 Lead EKG

• Nondiagnostic
• Suspicious for Ischemia
• Suspicious for Injury

Nondiagnostic EKG

• No ST or T wave abnormalities
• Does NOT rule out MI
• Not a candidate for reperfusion therapy
### Suspicious for Ischemia EKG
- ST depression or T wave inversion
- Does NOT rule out MI
- Not a candidate for reperfusion therapy

### Suspicious for Injury EKG
- Evidence of an MI
- ST elevation
- Candidate for reperfusion therapy

### Evidence of an MI
- Persistent chest pain or anginal equivalents
- Risk Factors
- ST elevation of 1mm or more in two anatomically contiguous leads

### Anterior Infarction

- Significant Q waves and T wave inversions in leads I, V2, V3 and V4
- Occlusion of proximal left anterior descending coronary artery

- ECG showing increased ST elevations in the anterior leads.
Anterior Leads

Anterior infarct, occlusion of left circumflex coronary artery.

Lateral Leads

Infarct, occlusion of right coronary artery.

Anterolateral Infarct

Oclusion of left circumflex coronary artery.

Inferior Infarct

Oclusion of right coronary artery.

Significant Q waves and T wave inversions in leads II, III, and aVF. With lateral damage, changes also may be seen in leads V4 and V6.
Inferior Leads

Lateral Leads

True Posterior Infarct

True Posterior Leads

- Mirror Test
Acute Anterior MI
S-T elevation, and T wave inversion in leads I, V2, V3, and V4

Reciprocal ST depression in leads III and aVF

Bundle Branch Blocks

- The Turn-Signal Rule
  - QRS >0.12 seconds throughout the ECG.
  - Look at the QRS in V1.
  - Identify the J point.
  - Draw a horizontal line.
  - Triangle pointing up indicates RBBB.
  - Triangle pointing down indicates LBBB.

Bundle Branch Blocks
- STEMI cannot be determined in the presence of a bundle branch block
- STEMI cannot be determined if QRS > .012 seconds (120mSec)
- A new LBBB is just as important as a STEMI
  - Must have old tracing to diagnose a new LBBB

Right Bundle Branch Blocks

- Terminal broad S wave in lead I. RSR' complex in lead V1.
Right Ventricular Infarct

• Rare but must be managed differently
• RVI is most commonly associated with an inferior wall infarct
  — Studies range from 10% to 50%
• Right ventricle is considered to be a low-pressure volume pump
  — Contractility is dependant on diastolic pressure

Assessment of an RVI

• Distended neck veins
• Clear lung fields
• Hypotension
• ST elevation in Leads II, III, and aVF
• ST elevation in lead V4R
• These patients are very sensitive to preload reducing agents such as nitro and MS
Right Ventricular Infarct

- ST elevation in leads II, III, and aVF
- Note that the elevation is greater in lead III than lead II
  - Typical for inferior MI with RVI

Management of an RVI

- Extreme caution must be used with nitro and MS
  - Use small incremental doses of MS
  - NTG best given by drip
- Fluid therapy if hypotensive
- Vasopressors if fluid is ineffective
  - Dopamine
  - Dobutamine

Wolff-Parkinson-White Syndrome

- WPW is a syndrome of pre-excitation of the ventricles due to an accessory pathway called the Bundle of Kent which is an abnormal pathway from the atria to the ventricles.
- Effects 0.15 to 0.2% of the population
- Normally asymptomatic
Wolff-Parkinson-White Syndrome

- Risk of sudden death due to tachydysrhythmias (rare)
- Produces a delta wave
  - Slurred upstroke in the QRS complex with a short PRI
  - Type I WPW produces positive delta waves
  - Type II WPW produces negative delta waves
- Commonly causes syncope and/or palpitations
Practice 1

- ST Elevation in Leads __________________________ (Anterior)
- ST Elevation in Leads ______ and _______ (Anterolateral)
- Reciprocal ST Depression in _____ and _____
- What is the interpretation?
- __________________________ Infarct

Practice 2

- ST Elevation in Leads __________________________(Anterior)
- ST Elevation in Leads ______, an _______(Lateral)
- Reciprocal ST Depression in ______ and ______
- What is the interpretation?
- __________________________ Infarct
Practice 3

Key Points

- A normal 12-lead ECG does NOT rule out an MI
- You cannot see ST elevation without a 12-lead ECG
- ST elevation is presumptive evidence of an MI until proven otherwise
- Other conditions may cause ST elevation

Key Points

- Being able to pinpoint the exact location of an infarct is less important than being able to recognize that an MI is occurring
- Always maintain a high index of suspicion
- LISTEN to your patient
- Get history and risk factors
- Practice, Practice, Practice

• ST Elevation in leads ______________________________ (Inferior)
• Reciprocal ST Depression in _______ and _______
• What is the interpretation?
• ______________________________ Infarct
Most Importantly......

TREAT THE PATIENT, NOT THE MONITOR