Understanding 12-Lead EKG’s

Basic 12-Lead interpretation

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Objectives

• Discuss basic 12-Lead interpretation methods and normal 12-Lead EKG findings
• Correctly interpret a 12-Lead EKG with ST elevations (STEMI)
• Correctly identify the area of coronary infarction and associated culprit coronary artery
• Correctly identify basic conduction defects on 12-Lead EKG’s
History of electrocardiogram

- **1887** - British physiologist Augustus D. Waller of St Mary's Medical School, London publishes the first human electrocardiogram. It is recorded with a capillary electrometer from Thomas Goswell, a technician in the laboratory. *Waller AD. A demonstration on man of electromotive changes accompanying the heart's beat. J Physiol (London) 1887;8:229-234*

- **1889** - Dutch physiologist Willem Einthoven sees Waller demonstrate his technique at the First International Congress of Physiologists in Bale. Waller often demonstrated by using his dog "Jimmy" who would patiently stand with paws in glass jars of saline.

- **1895** - Einthoven, using an improved electrometer and a correction formula developed independently of Burch, distinguishes five deflections which he names P, Q, R, S and T. *Einthoven W. Ueber die Form des menschlichen Electrocardiogramms. Arch f d Ges Physiol 1895;60:101-123*
Einthoven’s Triangle; Standard Limb Leads

- **Lead I** Right arm (RA) (−) to Left arm (LA) (+) displays lateral wall activity
- **Lead II** RA (−) to left leg (LL) (+) displays Inferior wall activity
- **Lead III** LA (-) to LL (+) displays a different angulation of inferior wall activity

The right leg (RL) acts as the ground or common
Augmented Leads

• \textbf{aVR} – Right Arm
• \textbf{aVL} – Left Arm
• \textbf{aVF} – Left Foot
• Unipolar – Only one Pos(+) pole and a reference point in the center of the heart
• Augmented – Voltage must be amplified by 1.5 fold
• Same electrode placement as Limb Leads
Frontal Plane

- $aV_R$ at $-150^\circ$
- $aV_L$ at $-30^\circ$
- $aV_R$ at $+30^\circ$
- $aV_L$ at $+30^\circ$
- $aV_F$ at $-90^\circ$
- $aV_F$ at $+60^\circ$
- $aV_F$ at $+120^\circ$
- $aV_F$ at $0^\circ$

Axes:
- I
- II
- III
Precordial leads or V - Leads

• Right arm, Left arm and Left leg combine to make the negative pole. Focus of the negative pole is in the center of the triangle.
V – Lead placement

- **Lead V1** - 4th intercostal space on the right side of the sternum
- **Lead V2** - 4th intercostal space on the left side of the sternum
- **Lead V3** - 5th intercostal space midway between V4 and V2
- **Lead V4** - 5th intercostal space midclavicular
- **Lead V5** - 5th intercostal space midway between V4 and V6
- **Lead V6** - 5th intercostal space midaxillary
Impulse origin and atrial depolarization

- When the SA node, a pacemaker cell, fires off an impulse, the impulse travels down and toward the right and left atria.
- The electrical flow is translated to the ECG as the P wave. The waveform is relatively small – normally between 1.5 and 2.5 mm in width and less than 3 mm in height.
PR interval = 0.12 – 0.20 sec (120 – 200 ms)
Septal depolarization

• The electrical flow stops briefly at the AV node, then travels quickly down the common bundle (Bundle of His) and through the right and left bundle branches to the interventricular septum.

• The depolarization of the septum causes a small deflection – a Q wave in some leads and a small R wave in others.
Apical and early ventricular depolarization

- After depolarizing the septum, the impulse moves downward and to the left.
- This results in a large waveform – either an "R" wave or an "S" wave
Late ventricular depolarization

- The final stage of depolarization takes place in the furthest stretches of the ventricle.
- The electrical stimulus moves upward, resulting in either a taller "R" wave or a smaller "S" wave.
Normal QRS = 0.06 - 0.11 sec (60-110 ms)
Ventricular Repolarization

• Finally, the electrical stimulus is completed, ending depolarization. The ions in the cells move back into their normal resting positions, from top to bottom, causing the T wave. The T wave should be the same vector as the mean QRS.
Normal QT interval $\leq 0.40$ sec & ST segment has no elevation or depression
• Atrial depolarization = P wave
• Septal depolarization = Q wave
• Early ventricular depolarization = tall R or S wave
• Late ventricular depolarization = taller R wave or S wave after R wave
• Ventricular repolarization = T wave
Normal 12 – Lead EKG

- **Standard Leads**
  - Standard leads are used to measure the electrical activity of the heart from the standard positions.
  - The axis between leads I & II is approximately 120 degrees.

- **Augmented Leads**
  - Augmented leads are used for amplification and are placed on the chest.
  - The axis of aVR is approximately +30 degrees.

- **Chest leads**
  - Chest leads are used to monitor the heart's electrical activity in the chest region.

**Rhythm Strip**
- 25mm/s, so Rate = 60 x 25/20 = 75 bpm
- Noise is present in the EKG tracing.

**Calibration**
- The calibration is indicated at the top right corner of the EKG tracing.
Normal is relative....

• It is important to remember that there is a wide range of normal variability in the 12 lead ECG
• It takes considerable ECG reading experience to discover all the normal variants
• Only by following a structured method of ECG interpretation and correlating the various ECG findings with the particular patient's clinical status will the ECG become a valuable clinical tool
Rapid 12 – Lead interpretation

• Rate
• Rhythm
• Axis determination
• Conduction abnormalities:
  • Atrioventricular blocks
  • Bundle branch blocks
  • Others
• Ischemia, injury and infarction
  • T-wave inversions
  • ST segment elevation
  • Significant Q waves
• **Acute MI pattern:**
  • **Anterior:**
    • ST elevation in V1, V2, V3, V4
    • ST depression in II, III, aVF
  • **Inferior:**
    • ST elevation in II, III, aVF
    • ST depression in V1, V2, V3, or I, aVL
  • **Lateral:**
    • ST elevation in I, aVL, V5, V6
    • ST depression in II, II, aVF
  • **Septal wall:** ST elevation in I, aVL, V1, V2
  • **Posterior:** tall wide R waves and ST depression in V1, V2
"Normal 12-Leads"
• Rate
• Rhythm

• **Axis determination**

• Conduction abnormalities:
  • Atrioventricular blocks
  • Bundle branch blocks
  • Others

• Ischemia, injury and infarction
  • T-wave inversions
  • ST segment elevation
  • Significant Q waves
Axis Deviation

• Causes of axis deviations
  • Chamber enlargement
  • Conduction defects
  • Pulmonary disease
  • AMI

• Identify axis deviation by Quadrant
  • Lead I
  • Lead aVF
Normal Axis

• Lead I
  • Positive or upwards deflection

• Lead aVF
  • Positive or upwards deflection
Left Axis Deviation

- Lead I
  - Positive deflection
- Lead aVF
  - Negative deflection
Right Axis Deviation

- Lead I
  - Negative or downwards deflection
- Lead aVF
  - Positive deflection
Far Right Axis Deviation (Indeterminate)

- Lead I
  - Negative or downwards deflection
- Lead aVF
  - Negative or downwards deflection
• Rate
• Rhythm
• Axis determination

**Conduction abnormalities:**
  • Atrioventricular blocks
  • Bundle branch blocks
  • Others

• Ischemia, injury and infarction
  • T-wave inversions
  • ST segment elevation
  • Significant Q waves
Intra-Ventricular Blocks
Right Bundle Branch Block
Left Bundle Branch Block

Diagram illustrating the transverse plane with electrocardiogram (ECG) tracings showing characteristic QRS complexes for left bundle branch block (LBBB). The ECG tracings in V1 and V6 show a delayed R wave with a prolonged QRS complex, indicative of LBBB.
59 Year-old with chronic bronchitis
83 year old with aortic stenosis
84 year old woman with HTN
90 year old woman, c/o syncope
70 year old man with exercise intolerance
• Rate
• Rhythm
• Axis determination
• Conduction abnormalities:
  • Atrioventricular blocks
  • Bundle branch blocks
  • Others

• Ischemia, injury and infarction
  • T-wave inversions
  • ST segment elevation
  • Significant Q waves
Extent of Myocardial Damage

• Determine:
  • Ischemia
  • Injury
  • Infarct

• All are caused by a decreased supply of blood to myocardial tissues
• Extend of damage determined by length of time without blood supply and oxygen
Ischemia

• Ischemia is reversible by restoring blood and oxygen supply to tissues

• During an ischemic event you may see the flattening and then inversion of T waves and/or progression of ST-T segment changes
ST Segment Changes

Baseline

Quantity or depth of ST-segment depression
ST Segment Changes

- **UPSLOPING** – very nonspecific for the diagnosis of ischemia. Associated with a lot of false positive exercise tests.

- **HORIZONTAL** – likely associated with ischemia.

- **DOWNSLOPING** – almost certainly associated with an ischemic myocardium.
Injury or Acute MI

• Caused by a prolonged period of little or no blood flow to the heart tissue
• Reversible if corrected **quickly**
• Characterized by hyperacute ST-T wave changes in ECG leads that correlate to specific areas of the heart without adequate oxygenation
• Higher the ST-T wave changes indicates more tissue involved (more proximal occlusion)
• May take several days to resolve
Infarct or Necrosis

- Not reversible

- Characterized by a Q wave > 1/3 of the R wave

Figure 27-8 (A) Normal QRS complex. (B) A pathologic Q wave indicates a transmural myocardial infarction.
NSTEMI, Sub-Endo MI or Non Q wave MI

• MI affecting only a partial thickness of the myocardium
• Possible normal 12-Lead or ST depression
• Positive cardiac enzymes
• Normal Q waves in lead aVR
STEMI

• ST segment elevation
  • 2 or more contiguous leads

• Often, positive cardiac enzymes (Trop I and CKMB)
  • Potential for negative enzymes on initial draw
Always consider cardiac markers

Days after MI Onset

Multiples of the AMI cutoff Limit

0 1 2 3 4 5 6 7 8

- Myoglobin
- Cardiac Troponin
- CK-MB
- Cardiac Troponin after unstable angina
Interpretation of MI

**Circumflex supplies**: Posterolateral LV, sometimes inferior LV, may also supply posterior left bundle and A-V node.

**LAD supplies**: Anterior and anterolateral LV, 2/3 septum, medial anterior RV, lower 1/3 posterior RV

**RCA supplies**: Anterior RV, upper ½ (basal) posterior wall, posterior 1/3 septum, posterior left bundle, inferior LV, usually AV and proximal HIS bundle via AV nodal branch.

SA node?  RCA 55%, LCA 45%, dual 10%
• Circumflex Artery (Cx)
  • Lateral leads on 12-lead
    • Leads I, aVL, V5, V6

• Right Coronary Artery (RCA)
  • Inferior leads on 12-lead
    • Leads II, III, aVF

• Left Anterior Descending Artery (LAD)
  • Anterior leads on 12-lead
    • Leads V1 – V4
Lateral MI

Oclusion of left circumflex coronary artery, marginal branch of left circumflex artery, or diagonal branch of left anterior descending artery.

ECG tracings showing abnormalities in leads I, aVL, aVF, II, III, and V4.
Inferior MI
Anterior MI

Occlusion of proximal left anterior descending coronary artery

Electrocardiogram (ECG) tracings:
- I
- aVR
- aVL
- V1
- V2
- V3
- V4
- V5
- V6
Diagnosing an MI

• ST elevations in 2 or more of the contiguous leads

• Reciprocal changes in adjacent leads

• Assume MI for any positive cardiac enzymes (Trop I – sensitive to myocardial ischemia)
ACUTE SEPTAL MI

Reciprocal changes
II, III, AVF

ST Elevation V2, V3

ACUTE INFERIOR AND SEPTAL MI

Reciprocal changes in I, AVL

ST Segment Elevations are seen in III, AVF, V2 and V3
<table>
<thead>
<tr>
<th>I</th>
<th>aVR</th>
<th>V1</th>
<th>V4</th>
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<tbody>
<tr>
<td>Lateral MI</td>
<td></td>
<td>Septal MI</td>
<td>Anterior MI</td>
</tr>
<tr>
<td>II</td>
<td>aVL</td>
<td>V2</td>
<td>V5</td>
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<tr>
<td>Inferior MI</td>
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<td>Septal MI</td>
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<td>III</td>
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<td>Inferior MI</td>
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Right Coronary Artery (RCA)
Circumflex Artery (Cx)
Left Anterior Descending Artery (LAD)
Lets Practice

• Identify ischemia or infarction

• Identify area of heart affected (culprit vessel)

• Watch for reciprocal changes
Practice Makes Perfect (or at least better)

• Find as many 12-Leads to read as you can!
• Ignore the computer diagnosis until after YOU have interpreted the 12-Lead
• Talk through your rational with other staff
• Ask questions if you are not sure:
  • Charge Nurse
  • MD or NP/PA
Online Resources

• University of Utah ECG Learning Center  http://ecg.utah.edu/
• Learn the Heart  http://www.learntheheart.com/
• EMS 12-Lead  http://www.ems12lead.com/