12 Lead ECG Fundamentals

Cardiovascular Boot Camp

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Normal 12 Lead ECG

STANDARD LIMB LEADS  AUGMENTED LIMB LEADS  CHEST OR PRECORDIAL LEADS

BIPOLAR  UNIPOLAR LEADS
### Two Sets of Leads

**Limb Leads**
- *Standard Limb Leads*  
  (I, II, and III)
- *Augmented Limb Leads*  
  (aVR, aVL, aVF)

**Chest Leads**
- Also called precordial leads
  - V1 – V6
Bipolar and Unipolar Leads

**Bipolar Leads**
- One positive electrode
- One negative electrode
- Records difference in electrical potential between selected electrodes
- Leads I, II, and III

**Unipolar Leads**
- One positive electrode
- One reference point
  - Zero electrical potential
  - Center of heart
- Leads aVR, aVL, aVF
- V1 – V6

Importance of the Positive Electrode

Reason 1

- Consider the positive electrode the “eye” or “the camera”
Electrode Placement
Limb Leads

The Ground

- Note: Nothing travels toward the right leg as a positive electrode.

- The right leg is the ground used to absorb any excess electrical activity.
Standard Limb Leads
Leads I, II, III

BIPOLAR

Standard Limb Lead
Leads I, II, III

LEAD I
- 
+/
LEAD II
LEAD III
+

Augmented Limb Leads
Leads aVR, aVL, aVF

Augmented Limb Leads
Lead Placement: Leads aVR, aVL, aVF
Chest (Precordial) Leads (Unipolar Leads)
Electrode Placement
Chest (Precordial) Leads

- Lead V₁
  - 4th ICS, RSB
- Lead V₂
  - 4th ICS, LSB
- Lead V₃
  - Midway Between V₂ & V₄
- Lead V₄
  - L midclavicular line, 5th ICS
- Lead V₅
  - L anterior axillary line, same level as V₄
- Lead V₆
  - L midaxillary line, same level as V₄

Frontal vs. Horizontal Planes
A Closer Look at Chest Leads
The Point of View of the Positive Electrode

- V1 – Septum (RV)
- V2 – Septum
- V3 – Anterior
- V4 – Anterior
- V5 – Low Lateral
- V6 – Low Lateral

<table>
<thead>
<tr>
<th>Lead 1</th>
<th>Lead 2</th>
<th>Lead 3</th>
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<tbody>
<tr>
<td>Left Arm</td>
<td>aVR</td>
<td>Right Arm</td>
</tr>
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<td>High Lateral Wall</td>
<td>V1</td>
<td>4th ICS, RSB Septal Wall</td>
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<td></td>
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<td>V2</td>
<td>4th ICS, LSB Septal Wall</td>
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<tr>
<td></td>
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<td>L anterior axillary, same level as V4 Low Lateral Wall</td>
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</table>
**Electrical Conduction Pathway**

- SA Node
- Right and left Atrial Conduction
- AV Node
- Bundle of His
- Right and Left Bundle Branches
- Fascicles
- Purkinje Fibers

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**QRS Complex**

- Not every QRS complex contains a Q wave, R wave and S wave!!
- Q – always negative (below baseline)
- R – first positive above the baseline
- R' – second positive above the baseline
- S – negative deflection following R wave or second component to entirely – complex
- S' – second negative deflection
Let’s Practice

ST Segment

• In limb leads the ST segment is normally isoelectric but may be slightly elevated or depressed by less than 1mm

• In precordial leads ST segment is elevation is normally not more than 1 to 2 mm
T Waves

- Represents ventricular repolarization
- Slightly asymmetrical
- Usually oriented in the same direction as the previous QRS
- Not normally > than 5mm (limb leads) to 10 mm ( precordial) high

The Importance of the Positive Electrode

**Reason 2**

- If a wave of depolarization moves **TOWARD** the + electrode, the waveform on the ECG graph will be upright or +
The Importance of the Positive Electrode

Reason 2

• If a wave of depolarization moves **TOWARD** the – electrode, the waveform on the ECG graph will be downward or –

![Diagram showing waveforms and depolarization directions]

A biphasic wave form occurs when the direction of depolarization is **PERPENDICULAR** to the + electrode

![Diagram showing a biphasic waveform]
A Closer Look at Lead I

• Lead 1 Normals
  – P waves: Upright and gently rounded
  – QRS Complex: Upright
  – T Waves: Upright and smaller than QRS

A Closer Look at Lead II

• Lead II normals
  – P wave: upright and gently rounded
  – QRS: upright
  – T wave: upright and smaller than QRS
A Closer Look at Lead III

- **Lead III normals**
  - P wave: upright and gently rounded
  - QRS Complex: Upright
  - T wave: Upright and smaller than QRS

A Closer Look at aVR

- **aVR Normals**
  - P wave: inverted
  - QRS: inverted (rSr’ or rS)
  - T wave: inverted
A Closer Look at aVL

• aVL Normals
  – P waves: Upright or inverted
  – QRS: Upright or inverted
  – T wave: Upright or inverted (but no down sloping of ST)

A Closer Look at aVF

• aVF Normals
  – P waves: upright and gently rounded
  – QRS: Upright
  – T wave: Upright and smaller than QRS
Normal V1-6: R Wave Progression

- The R wave becomes taller and the S wave becomes smaller as the electrode is moved from right to left.
- This pattern is called R wave progression.

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<td>V2</td>
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<td>Left Leg Inferior Wall</td>
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<td>4th ICS, LSB</td>
<td>L anterior axillary, same level as V4</td>
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<tr>
<td>V3</td>
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<td>Lead 3</td>
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- Lead 1: V1, 4th ICS, RSB, Septal Wall
- Lead 2: V2, 4th ICS, LSB, Septal Wall
- Lead 3: V3, Midway Between V2 & V4, Anterior Wall
- Lead 4: V4, L MCL, 5th ICS, Anterior Wall
- Lead 5: V5, L anterior axillary, same level as V4, Low Lateral Wall
- Lead 6: V6, L midaxillary line, same level as V4, Low Lateral Wall
12 Lead ECG Evaluation

1. Atrial rate
2. Ventricular rate
3. Regular / Irregular
4. P wave for each QRS
5. Underlying rhythm
6. Are P waves abnormal in any lead?
7. Calculate P-R Interval – is it constant or changing.
8. Is QRS width and shape normal in each lead?
9. If > 0.12 sec differentiate between RBBB and LBBB and ventricular ectopic focus by shape in V1 and V6.
10. Are ST segments normal in all leads? If abnormal, is the pattern repeated in a contiguous lead.
11. Are T Waves normal in all leads? If abnormal, is the pattern repeated in a contiguous lead?
12. What is the length of the QT interval?
13. What is the Axis?
14. If there is a pacemaker is it pacing, capturing and sensing in the appropriate chambers?
ECG Fundamentals
Calculating Cardiac Axis
Calculating the Electrical Axis of the Heart

- Axis is determined by the sum of all electrical activity
- As depolarization moves through the conduction pathway the direction is constantly changing; however the overall thrust of activity is in one direction
- The ventricle that requires the most of the depolarization activity is the ventricle which determines the direction of axis
- Normal is downward to the left

Bipolar Frontal Plane Leads

- **Lead I**
  - Left arm positive
  - Right arm negative
- **Lead II**
  - Left leg positive
  - Right arm negative
- **Lead III**
  - Left leg positive
  - Left arm negative
Unipolar Frontal Plane Leads

Reference point in center of chest – “telephoto lens”

- aVR
  - Right arm positive
- aVL
  - Left arm positive
- aVF
  - “Foot” (left leg) positive
Axis Quadrants:
Normal Axis

Axis Quadrants:
Right Axis Deviation

Causes:
RV Hypertrophy
Pulmonary Hypertension
Pulmonic Valve Stenosis
Chronic Lung Disease
Axis Quadrants: Left Axis Deviation

Causes:
- LV Hypertrophy
- Systemic Hypertension
- Hypertrophic Cardiomyopathy
- Aortic Valve Stenosis / Insufficiency

Axis Quadrants: Extreme Axis Deviation

Causes:
- Ventricular Tachycardia
Let Your Hands Determine Axis

- Use Lead I and aVF
- Left hand represents QRS in Lead I
- Right hand represents QRS in aVF
- Fingertips will point in the same direction as the QRS complex

"Handy" Method of Axis Calculation developed by J. Cooper, PhD., American College of CV Nursing

Normal Axis:
+0 to +90 Degrees

- Lead I: Upright QRS
- aVF: Upright QRS
- It’s always “normal” to be on the up and up
Right Axis Deviation:
+90 to +180 Degrees

- Lead I: Downward QRS
- aVF: Upward QRS
- Fingertips are facing each other, therefore, they are “right” together

Left Axis Deviation:
0 to –90 degrees

- Lead I: Upright QRS
- aVF: Downward QRS
- Fingertips are facing opposite directions, therefore they are “left” apart
**Extreme Axis:**
-90 to –180 Degrees

- Lead I: Downward QRS
- aVF: Downward QRS
- Fingertips are both facing downward therefore the axis is down and out and your fingers need to run for help

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**Axis Practice**
Axis Practice

Axis Practice
### Axis Practice

#### Lead 1
- **Left Arm**
- **High Lateral Wall**
- **Axis Quadrant**
- **aVR**
- **Right Arm**
- **V1**
  - 4th ICS, RSB
  - Septal Wall
- **V4**
  - L MCL, 5th ICS
  - Anterior Wall

#### Lead 2
- **Left Leg**
- **Inferior Wall**
- **aVL**
- **Left Arm**
- **High Lateral Wall**
- **V2**
  - 4th ICS, LSB
  - Septal Wall
- **V5**
  - L anterior axillary, same level as V4
  - Low Lateral Wall

#### Lead 3
- **Left Leg**
- **Inferior Wall**
- **Axis Quadrant**
- **aVF**
- **Left Leg**
- **Inferior Wall**
- **V3**
  - Midway Between V2 & V4
  - Anterior Wall
- **V6**
  - L midaxillary line, same level as V4
  - Low Lateral Wall
ECG Fundamentals
Bundle Branch Blocks

Conduction System Review

- Left Bundle Branch
  - Left anterior fascicle
  - Left posterior fascicle
- Right Bundle Branch
- Purkinje Network
- Purkinje Fibers
Normal Depolarization

QRS .06-.10 sec

Bundle Branch Block

- QRS complex is 0.12 sec or greater
- Incomplete BBB measures from 0.10 to 0.11
Right Bundle Branch Block

Causes

- CAD
- Disease of right side of the heart
- Cor pulmonale
- Cardiomyopathy
- Congenital lesions
- A-S Defects
- Pulmonic Stenosis
- Pulmonary Embolism

\[ V_1 = rsR' \]

\[ V_6 = qRS \]

QRS = .12 sec or more
Right Bundle Branch Block

- V1
  - Triphasic complex
  - rsR' pattern - positive
  - Or an M shaped R wave with right peak taller
  - Or a qR pattern

- V6
  - Triphasic complex
  - qRs with wide S waves
  - Positive

Left Bundle Branch Block

Causes

- Left Ventricular Hypertrophy
- MI
- CAD
- Aortic Stenosis
- Cardiomyopathy
- Hypertensive cardiomyopathy
Left Bundle Branch Block

- **V1**
  - Wide QS or rS complex - negative
  - Slick downstroke
  - Nadir <0.06 sec

- **V6**
  - Wide R wave with no initial septal q wave - positive

QRS = 0.12 sec or more
Left Bundle Branch Block
Nadir

- Measure from the beginning of the QRS complex to the bottom valley of the QRS

< 0.06 sec

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Let's Practice

ECG #3

[ECG tracing]

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QUESTIONS??

Thanks for Attending Cardiovascular Boot Camp

You may contact us at www.cardionursing.com

Rules of Life:
If you woke up breathing this morning, Congratulations! You get another chance. Use it wisely!

Thank You!