The 12-Lead ECG

• Objectives
  • Identify the normal morphology and features of the 12-lead ECG.
  • Perform systematic analysis of the 12-lead ECG.
  • Recognize abnormalities demonstrated on a 12-lead ECG indicating ischemia and infarction.
  • Discuss various non-ischemic alterations diagnosed through 12-lead EKG and their significance.
12-Lead ECG!!!
12-Lead ECG

- One of oldest tools and still vital tool to evaluate the heart

- Evaluates the electrical activity of the heart

- Also can reflect
  - the structure of the heart
  - function of the heart
  - blood flow to the heart muscle
  - effects of the heart to electrolyte imbalance
  - response of the heart to medications
12-Lead ECG

• Key to a good tracing:
  • Skin prep
  • Lead placement
Electrode placement

10 electrode placed

12 leads/views obtained
Electrophysiology
Electrical conduction in heart

- SA node (= pacemaker)
- AV node
- Bundle of His
- Right and left bundle branches
- Purkinje fibres
ECG Leads

• Lead = Electrical view of the heart

• A lead follows the flow of electricity from a negative pole to a positive pole
• Camera analogy:

• ECG waves look at the heart from different views or perspectives
Current direction and wave deflection
The 12-Lead

- Limb leads

- Augmented limb leads (augmented voltage)
- V leads
  - Also called unipolar, precordial or chest leads
  - V1-V6
  - Transverse view of the heart
The 12-Lead ECG
V Leads: R wave progression
Analyzing the 12-Lead ECG

• Develop a “method” to read the 12-lead
  
  • Helps to avoid missing anything of clinical importance!
Analyzing the 12-Lead

• Where to start:
  - Regularity
  - Rate
  - Evaluate waves and intervals
    - P wave
    - PR interval
    - QRS
    - T wave
    - U wave
    - QT interval
  - Identify other rhythm events
    - (PVCs, PACs, PJCs, etc.)
  - Determine the heart’s rhythm
    (sinus, atrial fib, etc.)
Examples:
The Normal 12-Lead ECG
• Analyze Waves and Intervals again by area of the heart:
  • P waves
  • QRS complexes:
    • R wave in lead II should be taller than lead I
    • The waves in lead III should be a smaller version of lead I
    • Note if the QRS is abnormally wide (bundle branch block)
  • R wave progression in the V leads
  • (P waves & QRS complexes are usually upright but may be inverted)
    • The QRS shouldn’t have a Q wave
    • ST segments: should be flat, on isoelectric line
    • T waves: peaked or inverted? flattened?
Abnormalities to watch for...

• Rate: too fast? too slow?
• Altered, variable, or absent P waves: sinus or atrial abnormality, AV block
• P waves not followed by QRS: complete heart block
• Prolonged or short PR intervals: heart block, junctional, re-entry tachy.
• Abnormal or widened QRS complexes: bundle branch block, ventricular tach.
• Premature beats: PAC, PJC, or PVCs
• Q waves (where there shouldn’t be Q waves): completed myocardial infarction
• Poor R wave progression in the V leads
• ST segment depression: myocardial ischemia
• ST segment elevation: myocardial infarction
• T wave abnormalities: myocardial ischemia, hyperkalemia
• U waves: electrolyte abnormality, medication
Note:

- Life-threatening rhythms (dysrhythmias)
  - Ventricular tachycardia
  - Ventricular fibrillation
  - Agonal rhythm
  - Extreme tachycardia
    - Sinus tachycardia
    - Supraventricular tachycardia
    - Atrial fibrillation or atrial flutter
    - Ventricular or wide-complex tachycardia
  - Extreme bradycardia
    - Sinus bradycardia
    - Heart block
    - Slow junctional or ventricular rhythms

...and initiate appropriate emergency protocol
12-Lead Interpretation

• The next step...

• Assessing axis
Evaluating the Electrical Axis

• Axis:
  • The average direction of the heart’s electrical activity during ventricular depolarization
  • Determining axis will help in determining ventricular size and function
  • Evaluate using the hexaxial reference system:
Axis

- Normal axis = 0 to 90 degrees  (some sources say -30 to 90)

- Right axis deviation = +90 to +180 degrees

- Left axis deviation = -0 to -90 degrees

- Axis between -180 to -90
  - Indeterminate axis
  - Northwest axis
  - “No man’s land”
Determining Axis

Two methods:

• Quadrant method:

  • Look at Lead I and AVF
  
  • Use your hands
    • Lead I = left hand
    • AVF = right hand
Normal Axis!
Example 2
Determining Axis

- **Degree method:**
  - 1. Select the limb lead with the largest QRS complex (most voltage)
  - 2. Locate the axis on the hexaxial diagram
  - 3. Evaluate that lead:
    - Deflection positive, move to higher number axis line on the diagram
    - Deflection negative, move to the lower number of the axis line on the diagram
Example
Example 2
Reasons for axis deviations

• **RAD:**
  - Right ventricular hypertrophy
  - Anterolateral MI
  - Left posterior hemiblock
  - Mechanical shifts
  - Acute pulmonary emboli
  - Severe pulmonary hypertension
  - Dextrocardia
  - A/V septal defects
Reasons for Axis Deviation

• **LAD:**
  - Inferior MI
  - Cardiac pacing
  - Left ventricular hypertrophy
  - Left bundle branch block
  - Ventricular arrhythmias
  - Mechanical shifts
    - Pregnancy, severe obesity

• **Indeterminate:**
  - Ventricular tachycardia
  - Extreme right ventricular hypertrophy

![ECG Image]
Recognizing ischemia and injury
ST Segment Changes...

- ST depression

- (Note: T wave inversion, flattening, or peaking also seen)

- ST elevation
Determining area of heart affected:

<table>
<thead>
<tr>
<th></th>
<th>I Lateral</th>
<th>aVR</th>
<th>V1 Septal</th>
<th>V4 Anterior</th>
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<tbody>
<tr>
<td>II Inferior</td>
<td>aVL Lateral</td>
<td>V2 Septal</td>
<td>V5 Lateral</td>
<td></td>
</tr>
<tr>
<td>III Inferior</td>
<td>aVF Inferior</td>
<td>V3 Anterior</td>
<td>V6 Lateral</td>
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</tbody>
</table>
ST Depression
T wave flattening and inversions
ST Elevation (with reciprocal changes)
Other Areas of MI

Right ventricular MI
- Evidence of inferior MI
- Right sided EKG:
  - ST elevation in V3R & V4R
- Patient may exhibit signs of right ventricular failure
  - Hypotension

Posterior MI
- Tall R wave in V1-V3
- With
  - ST segment depression and upright T wave
- Deep, flat ST depression
Right ventricular MI
Posterior MI
Q waves

- Indicate infarction has occurred
Non-ischemic ECG Changes
P Waves

• Right atrial enlargement (P pulmonale)
  
  • Indicating right atrial enlargement
  
  • Tall peaked P waves in lead II (> 2 small boxes) and V1 (> 1.5 mm)

• P waves indicating left atrial enlargement (P mitrale)
  
  • Notched P waves in lead II
  
  • Biphasic P wave in V1 with terminal P negative wave > 0.4 ms
Atrial Enlargement: Causes

- Right atrial enlargement:
  - Pulmonary hypertension
  - COPD
  - Tricuspid stenosis
  - Primary hypertension

- Left atrial enlargement:
  - Systemic hypertension
  - Aortic stenosis
  - Mitral incompetence
  - Hypertrophic cardiomyopathy
QT Interval
Prolonged QT Interval

- The QT interval reflects the time required for electrical activity to occur within the ventricle
  - Includes both depolarization and repolarization

- Measure from beginning of QRS to the end of the T wave, normal 350-450 milliseconds

- Heart rate can affect QT so a formula used to correct for rate, QTc

- Prolonged QT intervals increase vulnerabilities to V. Tach
  - Particularly Torsades de Pointes
61 years, Male

- Vent. rate: 210 bpm
- PR interval: * ms
- QR8 duration: 176 ms
- QT/QTc: 286/534 ms
- P-R-T axes: * -71 -49

Undetermined rhythm
Left axis deviation
Nonspecific intraventricular block
Inferior infarct, age undetermined
Lateral injury pattern
*** ACUTE MI / STEMI ***
Abnormal ECG

Referred by:  Unconfirmed

Ivan Rios, www.EMS12Lead.com
Bundle Branch Blocks

- Impairment or block in conduction in either right or left bundles

- Right bundle branch

- Left bundle branch
  - Left anterior fascicle
  - Left posterior fascicle
Causes of bundle branch block

Right BBB
- Myocardial Infarction
  - Ischemic heart disease
- Hypertension
- Pulmonary embolism
- Infection of the heart
- May be congenital and present at birth

Left BBB
- Heart disease—acute MI
  - Ischemic heart disease
- Cardiomyopathy
- Hypertension
- Primary disease of the conduction system
- Infection of the heart
Bundle Branch Blocks

• If blocks occur, electrical conduction is passed slowly throughout the ventricle where the block is present

• The QRS will be wider than 0.12 seconds

• Right BBB
  • rSR’ upright in V1
  • T wave opposite the V1 QRS
  • V1 and V6 in both upright

• Left BBB
  • Wider than normal S wave
  • Large, deep QS in V1 or small R then wide S
  • T wave opposite the V1 QRS
  • V1 and V6 opposite
Hemiblock
(Left Anterior or Posterior Fascicular Block)

LAFB
• Left axis deviation
• Small R waves in inferior leads (II, III, and aVF)

LPFB
• Right axis deviation
• Small R and deep S in I, aVL
• Small Q in lead III
Chamber Hypertrophy

• Results from increases in pressure or volume or both
Chamber Hypertrophy

Right Ventricle
- COPD (most common cause)
- Pulmonary embolism
- Pulmonary stenosis
- Pulmonary hypertension
- Valvular disease
  - Mitral stenosis
  - Tricuspid insufficiency
- Congenital heart disease-
  - Tetralogy of Fallot
  - Transposition of the great vessels

Left Ventricle
- Hypertension (most common cause)
- Aortic valve disease
  - Aortic stenosis
  - Aortic regurgitation
- Hypertrophic cardiomyopathy
- Congenital heart disease-
  - Coarctation of the aorta
Chamber Hypertrophy

Right Ventricular
- Tall R wave in V1
- (Right ventricular depolarization)
- Right axis deviation
- T wave inversion

Left Ventricular
- R wave in V5 or V6
  plus
- S wave in V1 or V2 ≥ 35
- Left axis deviation may occur
- ST segment depression and T wave inversion in left leads
- Repolarization changes (left ventricular strain pattern)-ST depression & asymmetrical T waves
Right ventricular hypertrophy
Left ventricular hypertrophy
“Mr. Osborne, may I be excused? My brain is full.”
References


Helpful Websites

• ECG Learning Center, http://ecg.utah.edu/lesson/1

• ECG Library: http://www.ecglibrary.com/ecghome.php


• Life in the Fast Lane: http://lifeinthefastlane.com/ecg-library