Analysis of the 12 Lead ECG
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- I have no financial affiliations to disclose

Objectives

- At the conclusion of this session the participant will:
  1. Apply a 5 step approach to 12-lead ECG interpretation
  2. Analyze acute and chronic morphologic changes
  3. Determine axis with the hexaxial plot
  4. Evaluate learned concepts in a case study
Outline

• Propogation of the AP
  – Normal conduction
  – Axis deviation

• 5 Step Approach
  – Rate, rhythm, intervals, axis, morphology

• Case study

Vector Analysis and Axis Determination

• Initiation and Propagation – Sequence of Cardiac Activation
  – The SA node depolarizes spontaneously
  – Atrial muscle depolarizes rapidly
  – The wave of depolarization funnels to AV node where it is delayed
  – Current travels to the bundle of His

Vector Analysis and Axis Determination (cont’d)

  – Current divides into right and left bundles
  – Depolarization of interventricular septum is left to right
  – Current moves simultaneously through the right and left bundle branches
  – Ventricles repolarize
Initiation and Propagation

Source: S.K. Miller

Limb Leads

- Vector is a voltage force that has direction as well as amplitude
  - Electrical events in the heart occur in three dimensions
  - ECG paper converts those dimensions to a two dimension picture – hence 12 leads
  - Using 12 leads allows us to visualize events from the anterior, inferior, and lateral perspective

Limb Leads

- The leads
  - Offer a lateral and inferior view
  - Axis is plotted based on the hexaxial system
  - Find the limb lead with the voltage closest to 0
  - Identify its right angle lead
  - On the ECG, see if that lead is positive (+) or negative (-)
The Hexaxial Plot

The Hexaxial Plot

Source: S.K. Miller
Axis Determination

• Determine the corresponding direction on the hexaxial plot
• Because the net vector is normally down and to the left, the normal axis should be in the vicinity of 60° – a range of –30° to +110° is normal

Axis Determination

• If the axis deviates to the left of -30°, this represents a left axis deviation
• If the axis deviates to the right of +110°, this represents a right axis deviation

Source: S.K. Miller
The Hexaxial Plot

Source: S.K. Miller
The System of ECG Interpretation

1. Rate
2. Rhythm
3. Intervals
4. Axis
5. Morphology

Rate

• Determine the R-R interval
• Each large square is 0.2 seconds
• Divide the number of large squares between R waves into 300 to determine rate
• Normal rate is 60 to 100 bpm
Rhythm

• Rhythm interpretation is presumed as a prereq to this presentation!
• The second step in 12-lead ECG assessment is identification of the rhythm, e.g., NSR, SB, ST, A-V block, atrial dysrhythmia, ventricular dysrhythmia, etc.

Intervals

• P-R interval represents A-V conduction
  – Should be 0.12 to .22 seconds
  – Prolonged P-R interval indicates a first degree block
  – Shortened P-R interval indicates a junctional rhythm with retrograde conduction

Intervals

• QRS duration represents ventricular depolarization
  – Should be < 0.12 seconds
  – Prolonged duration indicates a block in the bundle branches or a ventricular ectopic foci
Intervals

- Q-T interval represents repolarization of the ventricle
  - Q-T interval should be < ½ the R-R interval
  - Long Q-T interval increases the risk of ventricular dysrhythmia and sudden death

QRS Axis

- Identify the lead where the net voltage of the QRS is closest to 0
- Look for the perpendicular lead
- If the deflection of the perpendicular lead is +, then the axis is at the positive end of the pole
- If the deflection of the perpendicular lead is -, then the axis is toward the negative end of the pole

Abnormalities Caused by Drugs and Metabolic Conditions
Abnormalities of Rate

• Sinus bradycardia
  – Beta adrenergic antagonists
  – Calcium channel antagonists
  – Digitalis
  – Adenosine
  – Hypoxemia
  – Hypothyroidism
  – Hypothermia
  – Hyperkalemia

Sinus Tachycardia

• Catecholamines
• Caffeine
• Amphetamines
• Hyperthyroidism
• Anemia
• Fever

Heart Block

• Digitalis
• Beta adrenergic blockers
• Calcium channel blockers
• Adenosine
• Hyperkalemia
Atrial Flutter/Fibrillation

- Flutter
  - Hypoxemia
- Fibrillation
  - Thyroid hormone
  - Hyperthyroidism

Ventricular Fibrillation

- Most antidysrhythmic drugs
- Digoxin
- Tricyclic overdose
- Hypokalemia
- Hypomagnesemia
- Hypocalcemia

Torsade de pointe

- Class I antidysrhythmics
- Amiodarone
- Phenothiazine derivatives
- Tricyclic overdose
- Long QT syndrome
Analysis of the 12-Lead ECG
Part 2
Morphologic Changes

Morphologic Changes

• The V leads (V₁ to V₆), aka precordial leads, represent the anterior wall of the heart
  – V leads may be referred to as “anterior” leads
  – The limb leads represent the inferior and lateral walls of the heart

<table>
<thead>
<tr>
<th>Inferior Wall</th>
<th>Lateral Wall</th>
<th>Anterior Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>II, III, aVF</td>
<td>I, aVL, (V₆)</td>
<td>V leads</td>
</tr>
</tbody>
</table>

P Wave Abnormalities

• The P wave represents atrial depolarization; an abnormal P wave would logically suggest an atrial abnormality
• Left atrial abnormalities
  – Biphasic P wave in V₁ is most common; must be 1 x 1 mm to be significant
  – Biphasic P waves occur in conditions that increase LVEDP
  – CHF, LVH, hypertensive heart disease may all cause this abnormality
P Wave Abnormalities

• Broad, notched P waves in limb leads suggest left atrial dilation
• These occur in conditions such as mitral stenosis and regurgitation

Right Atrial Abnormalities

• P wave > 2.5 mm in any lead
• Occurs in conditions such as lung disease and pulmonary artery hypertension
QRS Abnormalities

- Remember the normal flow of current and how it reflects on an ECG
  - ECG will record normal left to right activation in lead I – initial deflection is negative
  - LV depolarization produces an upward deflection
  - Late LV to RV current produces a negative deflection
  - After RV activation, return to baseline

QRS Abnormalities

- Right bundle branch block (RBBB)
  - QRS > 0.12 seconds
  - Remember that current normally moves left to right in the interventricular septum
    - ECG will record normal left to right activation in V₁
    - This is followed by normal LV activation
    - Late current LV to RV results in second upward deflection in V₁
    - After RV activation, return to baseline
Right Bundle Branch

Incomplete RBBB

- Usually a normal variant
- May reflect RV hypertrophy or dilation
- Very common with atrial septal defect
- RSR pattern in V₁
- QRS is < 0.12 seconds
Left Bundle Branch Block

- Sequence is opposite RBBB
- Loss of initial normal left to right activation
- Interventricular septum is activated from right to left, causing an abnormal upward deflection in the left lateral leads
- QRS is > 0.12 seconds
- Septum is activated from right to left, but the blocked left bundle limits the impulse

LBBB (continued)

- Right side depolarizes first; it is thin walled, so it produces a small current
- After RV depolarization, the current travels around to left ventricle
- Late left depolarization produces terminal QRS force
Fascicular Blocks

- The left bundle branch divides into two fascicles; the anterior and posterior
- LBBB is when both fascicles are blocked; QRS is wider than 0.12 seconds
- When only one of the fascicles is blocked, the diagnosis is either “left anterior fascicular block” or “left posterior fascicular block”
Fascicular Blocks

- Diagnosis of fascicular block is made when there is a shift in axis
- The QRS is not necessarily wider than normal
- LAFB is extreme left axis deviation, at least -45° and not caused by IWMI
- LPFB is diagnosed by right axis deviation, at least > 90°, usually > 110 to 120°

LAFB

The Hexaxial Plot
Bifascicular Block

- A right bundle branch block
  - RSR pattern in V₁
  - QRS > 0.12 seconds
- A coincident block of either the left anterior or posterior fascicle
- AKA – a RBBB with either left or right axis deviation
Left Ventricular Hypertrophy

- When you have hypertrophy of muscle, a variety of changes occur
  - The larger muscle mass produces more voltage
  - The increased size changes axis of electrical conduction
  - Resultant high pressure in left atria may change character of voltage movement through left atria
Romhilt + Estes
Point score system

• Amplitude – any of the following = 3 points
  – Largest R or S wave in any limb lead ≥ 20 mm
  – S wave in V1 or V2 ≥ 30 mm
  – R wave in V5 or V6 ≥ 30 mm
• ST-T strain (change in lateral leads)
  – On digitalis = 1 point;
  – Not on digitalis = 3 points

Romhilt + Estes
Point score system

• Left atrial abnormality = 3 points
• LAD > -30° = 2 points
• QRS duration ≥ 0.09 sec = 1 point
• Intrinsocoid deflection in V5 or V6 ≥ 0.05 sec = 1 point

5 or more points = LVH
4 points = probable LVH

Source: S.K. Miller
Right Ventricular Hypertrophy

- Most voltage in the QRS generated by LV
- When the right ventricle hypertrophies significantly, it can generate a lot of voltage; a more “rightward shift” occurs in V1

RVH

- Diagnostic criteria
  - R/S in V₁ > 1 or
  - R in V₁ + S in V₆ > 10.5 mm
- Supportive criteria
  - Right axis deviation > 110°
  - Right atrial abnormality
  - ST depression + T wave inversion in V₁ or V₂
Poor R Wave Progression

- In the normal ECG, the transition from negative $V_{1-2}$ to positive $V_{5-6}$ deflection occurs during $V_{3-4}$
- A delay or absence of this transition on ECG just means that anatomically the transition point has moved
Causes of PRWP

- COPD
- LV dilation
- Anterior wall MI
- Misplaced precordial leads
Low QRS Voltage

- QRS amplitude < 5 mm in all limb leads
- QRS amplitude in V leads usually < 10 mm, but not necessary for diagnosis

Causes of Low QRS Voltage

- Effusion
- Cardiomyopathy
- Hypothyroidism
- Obesity
- Emphysema
- Normal variant
ST-T Wave Abnormalities

- Ischemia and infarction tend to be regional events
- Depending upon anatomy, there may be some overlap

- An event in a large RCA that loops around the lateral wall might cause inferolateral ECG changes
- An event in a large anterior descending artery that has branches to the lateral wall may cause an anterolateral event
- An event in the left main artery may cause an anterolateral event
- Global ST-T changes are more typically caused by pericarditis

Arteries and Corresponding Leads

Source: S.K. Miller
ST Segment Depression

- Stenosed artery with some retrograde flow
- O2 demand exceeds supply
- Subendocardial ischemia
- Region of myocardium furthest from the stenosed artery is occluded
- If ischemia persists and myocardial injury occurs, a subendocardial MI occurs
  - Later changes will show T wave inversion

Subendocardial Injury

Source: S.K. Miller

ST Segment Elevation

- Most common cause is transmural MI
- Affected artery is totally occluded
- Is the primary ECG indication for thrombolytic therapy
- Prinzmetal's angina (acute vasospasm) usually produces complete vessel occlusion; will produce ST segment elevation if ECG recorded during event
ST Segment Elevation

- The size of the inferior and lateral MI is proportional to the sum of the elevation in the appropriate leads.
- The size of the anterior wall MI is proportionate to the number of anterior leads with elevation.

Source: S.K. Miller
Other Causes of ST Elevation

- There are causes of ST elevation that are not specific to myocardial damage
  - Pericarditis

Non-specific ST changes

- A label typically applied to ST depression that is not placed in a clinical context
- Specific ST changes
  - During exercise ECG
  - During chest pain
T Wave Inversion

- Reflects altered repolarization of ventricular muscle during ischemia/injury event
- May reflect permanent injury with scar formation and loss of muscle; permanent atypical path of repolarization

Q Waves

- Initial negative deflection of the QRS complex
- Must be 1 mm deep and 1 mm wide to be significant
- May be normal in leads III and V6
- A Q wave indicates transmural injury
Atypical Situations
WPW Syndrome

- Activation of accessory pathway results in preexcitation of the ventricle
- Delta wave may appear to be a Q wave
- No history of MI
- Normal echocardiogram
- Short P-R interval

Source: S.K. Miller
• Rate ______________
• Rhythm ______________
• Intervals ______________
  P-R ______________
  QRS ______________
  Q-T ______________
• Axis ______________
  Deviation? ______________

The Hexaxial Plot

Source: S.K. Miller
• Morphology
  – P Wave abnormality
  – Bundle branch block
  • Right or Left
  • Incomplete RBBB
  • LAFB or LPFB
  • Bifascicular block

• LVH
• RVH
• PRWP
• Low QRS voltage
• St-T abnormality
• Q wave

• Interpretation
End of Presentation!
Thank you for your time and attention.

References