EKG CONFERENCE

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April 12    June 14
A “Method” of EKG Reading

- This "method" is recommended when reading 12-lead ECG's. Like the approach to doing a physical exam, it is important to follow a standardized sequence of steps in order to avoid missing subtle abnormalities in the ECG tracing, some of which may have clinical importance. The 6 major sections in the "method" should be considered in the following order:

1. Measurements
2. Rhythm analysis
3. Conduction analysis
4. Waveform description
5. ECG interpretation
6. Comparison with previous ECG (if available)
• 1. MEASUREMENTS (usually made in frontal plane leads):
  - Heart rate (state both atrial and ventricular rates, if different)
  - PR interval (from beginning of P to beginning of QRS complex)
  - QRS duration (width of most representative QRS)
  - QT interval (from beginning of QRS to end of T)
  - QRS axis in frontal plane

2. RHYTHM ANALYSIS:
   - State the basic rhythm (e.g., "normal sinus rhythm", "atrial fibrillation", etc.)
   - Identify additional rhythm events if present (e.g., "PVC's", "PAC's", etc)
   - Remember that arrhythmias may originate in the atria, AV junction, and ventricles

3. CONDUCTION ANALYSIS:
   - "Normal" conduction implies normal sino-atrial (SA), atrio-ventricular (AV), and intraventricular (IV) conduction. The following conduction abnormalities are to be identified if present:
     - 2nd degree SA 'exit' block (type I, type II, or uncertain)
     - 1st, 2nd (type I or type II), and 3rd degree AV block
     - IV blocks: bundle branch, fascicular, and nonspecific blocks
     - Exit blocks are blocks just distal to the sinus or an ectopic pacemaker site

• 4. WAVEFORM DESCRIPTION:
   - Carefully analyze each of the 12-leads for abnormalities of the waveforms in the order in which they appear: P-waves, QRS complexes, ST segments, T waves, and... Don't forget the U waves.
   - P waves: are they too wide, too tall, look funny (i.e., are they ectopic), etc.?
   - QRS complexes: look for pathologic Q waves, abnormal voltage, etc.
   - ST segments: look for abnormal ST elevation and/or depression.
   - T waves: look for abnormally inverted T waves or unusually tall T waves.
   - U waves: look for prominent or inverted U waves.

• 5. ECG INTERPRETATION:
   - This is the conclusion of the above analyses.
   - Interpret the ECG as "Normal", or "Abnormal". Occasionally the term "borderline" is used if unsure about the significance of certain findings or for minor changes.
   - List all abnormalities. Examples of "abnormal" statements are: 8 Inferior MI, probably acute
     - Old anteroseptal MI
     - Left anterior fascicular block (LAFB)
     - Left ventricular hypertrophy (LVH)
     - Right atrial enlargement (RAE)
     - Nonspecific ST-T wave abnormalities
     - Specific rhythm abnormalities such as atrial fibrillation
Arrhythmias

• Rhythm Analysis is best understood by considering characteristics of impulse formation and impulse conduction

• Impulse Formation
  • Site of Origin: Where does the rhythm originate?
    • Sinus Node
    • Atria (PAC, Ectopic Atrial Rhythms)
    • AV Junction (PJC and Junctional Rhythm)
    • Ventricle: (PVC)

• Impulse Formation
  • Rate
  • Regularity
  • Onset: how does arrhythmia begin
    • Active Onset (PAC, PVC, PSVT)
    • Passive Onset (Junctional or Escape beats or rhythm)
Arrhythmias

- Rhythm Analysis is best understood by considering characteristics of impulse formation and impulse conduction

- Impulse Conduction – how does the rhythm conduct through the heart chambers
  - Antegrade (forward) vs Retrograde (backward) conduction
  - Will Discuss Conduction Blocks during next lecture
<table>
<thead>
<tr>
<th>Site of Origin</th>
<th>Single Events</th>
<th>Slow Rates (&lt;50 bpm)</th>
<th>Intermediate Rates (50-99 bpm)</th>
<th>Fast Rates (≥100 bpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus</td>
<td></td>
<td>Sinus bradycardia</td>
<td>Normal sinus rhythm</td>
<td>Sinus tachycardia</td>
</tr>
<tr>
<td>Atria</td>
<td>PAC’s</td>
<td></td>
<td>Ectopic atrial rhythm, Atrial fibrillation, Atrial flutter (e.g., 4:1 block)</td>
<td>Paroxysmal SVT, Atrial fibrillation, Atrial flutter (2:1 block), Ectopic atrial tachycardia, Multifocal atrial tachycardia</td>
</tr>
<tr>
<td>AV Junction (AVN, His)</td>
<td>PJC’s J- escape beats</td>
<td>J- escape rhythm (~40-50 bpm)</td>
<td>Accelerated J- rhythm (~55-100 bpm)</td>
<td>Junctional tachycardia, Paroxysmal SVT: AVNRT, AVRT (WPW)</td>
</tr>
<tr>
<td>Ventricles (Wide QRS)</td>
<td>PVC’s V-escape beats</td>
<td>V- escape rhythm (~35-45 bpm) aka: ‘Idioventricular Rhythm’</td>
<td>Accelerated V- rhythm (~50-100 bpm)</td>
<td>Ventricular tachycardia, Torsade de points, Ventricular fibrillation</td>
</tr>
</tbody>
</table>
Premature Atrial Complex

- Occur as single or repetitive events and have unifocal or multifocal origins:

- Three Different Outcome depending on the degree of maturity (coupling interval from preceding sinus P waves) and the preceding cycle length (the RR interval)

- **Non-conducted PAC** – AV Node Still Refractory

- **Conducted with Aberration** – PAC conducts into the ventricle but finds one of the two bundle branches

- **Normal Conduction**

- The pause after PAC is usually incomplete – the PAC enters the sinus node and resets its timing causing the next

- Contrast to PVC which have complete pause

- Pattern:
  - Bigeminy
  - Trigeminy
  - Couplet
  - Triplet
Premature Atrial Complex

Non-conducted

Conducted with Abberation
Premature Atrial Complex
Premature Junctional Complex

• Similar to PAC’s in clinical implication, but less frequent.
• The PJC focus in the AV Junction captures the atria (retrograde) and the ventricles (antegrade)
• The retrograde P wave may appear **before, during, or after the QRS complex**
Premature Junctional Complex
Supraventricular Tachyarrhythmia

- Fast/Narrow Regular:
  - Sinus Tachycardia
  - Ectopic Atrial Tachycardia
  - Junctional Tachycardia
  - Atrial Flutter
  - AVRT
  - AVNRT

- Fast/Narrow Irregular
  - Atrial Fibrillation
  - Multifocal Atrial Tachycardia
  - Sinus Tachycardia with PACs
Ectopic Atrial Tachycardia

- Ectopic, discrete looking, unifocal P’ waves with Atrial Rates 100-250 bpm
- Ectopic P’ waves usually precede QRS complexes P’R interval < RP’ interval (PSVT has retrograde P waves right after the QRS complex)
- QRS complexes usually normal morphology unless pre-existing bundle branch block or accessory pathway

- Etiologies: Digoxin Toxicity, Atrial Scarring, Catecholamine Excess, Congenital Abnormalities, or idiopathic
- It’s Called Ectopic Atrial Rhythm when atrial rate < 100 bpm
Junctional Rhythm and Tachycardia

- **Classification based on rate:**
  - **Junctional Escape Rhythm:** 40-60bpm
  - **Accelerated Junctional Rhythm:** 60-100bpm
  - **Junctional Tachycardia:** > 100bpm
- **Junctional Escape Beats:** passive, protective beats originating in subsidiary pacemaker cells in the AV junction.
  - Programmed to occur whenever the primary pacemaker defaults or AV node blocks the atrial impulse.
  - Basic firing rate: 40-60bpm
- **Junctional Escape Rhythm:** sequence of three or more junctional escape beats occurring by a rate of 40-60bpm
- **Accelerated Junctional Rhythm:** this is an active junctional pacemaker rhythm caused by events that perturb the pacemaker cells in AV Junction
- **Junctional Tachycardia:** usually begins as AJR but the heart rate gradually increases to > 100bpm.
  - Ischemia (RCA occlusion in Inferior MI) and Digitalis Toxicity are two MCC
Junctional Rhythm and Tachycardia

• EKG Morphology:
  - Narrow Complex, QRS < 120msec (unless pre-existing BBB or aberrant conduction)
  - Retrograde P wave maybe present and can appear before (A), during (B), or after (C) QRS complex
  - Retrograde P waves are usually inverted in inferior leads (II, III, aVF) AND upright aVR + V1
Atrial Flutter

- Caused by a re-entry circuit within the right atrium – two types clockwise and anti-clockwise re-entry.
  - Anticlockwise: inverted flutter waves in inferior leads
  - Clockwise: positive flutter in inferior leads
- Regular Atrial activity with a saw-tooth appearance (more discrete looking P wave in V1).
- Atrial Rate: 250-350bpm
- Ventricular Response: 2:1, 3:1 (rare), 4:1, or Variable depending on AV conduction properties.
- Ventricular Rate is a fraction of the atrial rate:
  - 2:1 Block = 150 bpm
  - 3:1 Block = 100 bpm
  - 4:1 Block = 75 bpm
- In Atrial Flutter with Variable Block the RR intervals will be multiples of PP interval
Multifocal Atrial Tachycardia

- A rapid, irregular atrial rhythm arising from multiple ectopic foci within the atria
- At least three distinct P-wave morphologies in the same lead. Isoelectric baseline between P-waves (no flutter waves)
  - Absence of a single dominant atrial pacemaker
- Atrial Rate: > 100bpm (usually 100-250bpm)
- Ventricular Response: Irregularly Irregular
- Most Commonly seen in patient’s with hypoxia/hypercarbia (ie. COPD or HFrEF Exacerbation)
- Development of MAT during an acute illness is poor prognostic indicator
- It’s called a Wandering Pacemaker when rate is below 100bpm
Multifocal Atrial Tachycardia
Atrial Fibrillation

- Irregularly Irregular Rhythm
- Atrial activity is poorly defined; may see course or fine baseline undulations. **No distinct P waves.**
- Ventricular Response is Irregularly Irregular and maybe fast (> 100bpm), moderate (60-110bpm), or slow (< 60bpm)
- **Afib with WPW:** can occur in 20% of patients with WPW.
  - Accessory pathway allows for rapid conduction directly to the ventricles bypassing the AV Node
  - Rate > 200 bpm, Wide QRS complex, Axis remains stable (unlike polymorphic VT)

Classification of Atrial Fibrillation:

- **Paroxysmal AF:** Self-terminating episodes < 7 days
- **Persistent AF:** Not self-terminating, duration > 7 days
- **Chronic AF:** duration > 1 yr
- **Permanent AF:** duration > 1 yr in which rhythm control interventions are not pursued or are unsuccessful.
AVRT: Atrioventricular Re-entrant Tachycardia

- A Re-entry circuit is formed by the normal conduction system and the accessory pathway resulting in a circus movement
- During tachyarrhythmias the feature of pre-excitation are lost as accessory pathways forms part of re-entry circuit
- **AVRT often triggered by PAC/PVC**
- **AVRT is further divided into Orthodromic or Antidromic Conduction**
AVRT: Orthodromic Conduction

- **Antegrade Conduction**: via AV node
- **Retrograde Conduction**: via Accessory Pathway
- **EKG Morphology**:
  - Rate: 200-300bpm
  - P waves maybe buried in QRS complex or retrograde
  - QRS complex usually < 120ms
  - Can have QRS Alternan
  - T wave inversion and ST Segment depression common

- **Treatment**:
  - Stable: Vagal Maneuvers. Followed by Adenosine or CCB
  - Unstable: Synchronized DC Cardioversion
AVRT: Antidromic Conduction

- **Antegrade Conduction occurs via accessory pathway**
- **Retrograde Conduction occurs via AV node**
- **EKG Morphology**
  - Rate: 200-300bpm
  - Wide QRS complexes due to abnormal ventricular depolarization via accessory pathway (mistaken for Vtach)
- **Treatment:**
  - Stable: Can use Amiodarone, Procainamide, or Ibutilide
  - Unstable: Synchronized DC Cardioversion
AVNRT: Atrioventricular Nodal Reentrant Tachycardia

- AV Node becomes pacemaker, action potentials are fired in a retrograde direction to the atria and antegrade to ventricles caused by re-entry circuit
  - Creation of two pathways: fast and slow pathways which are in or near the AV node
- From Diagram:
  - Alpha is fast pathway but has a longer refractory period.
  - Beta is a slower pathway but has a shorter refractory period.
**AVNRT: Atrioventricular Nodal Reentrant Tachycardia**

- **Slow-Fast Pathway: 80-90%**
  - Anterograde Conduction: Slow AV Node Pathway
  - Retrograde Conduction: Fast AV Node Pathway
  - EKG Morphology:
    - Retrograde P wave hidden or at end of QRS complex
    - Typically see SVT appearance with absent P waves

- **Fast-Slow Pathway: 10%**
  - Anterograde Conduction: Fast AV Node Pathway
  - Retrograde Conduction: Slow AV Node Pathway
  - EKG Morphology:
    - Retrograde P wave appears after QRS
    - QRS – P – T Complex
Practice EKGs
Afib w/ RVR
Atrial Flutter with 2:1 Block
Ectopic Atrial Tachycardia
Junctional Tachycardia
Afib w/ WPW Pre-excitation
Atrial Flutter with Variable Block
AVNRT
Atrial Flutter with 4:1 Block