Cardiology/EKG
Board Review

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Objectives

- Review general method for EKG interpretation
- Review specific points of “data gathering” and “diagnoses” on EKG
- Review treatment considerations
- Review clinical cases/EKG’s
- Board exam considerations
EKG
EKG – 12 Leads

- Anterior Leads - V1, V2, V3, V4
- Inferior Leads – II, III, aVF
- Left Lateral Leads – I, aVL, V5, V6
- Right Leads – aVR, V1
11 Step Method for Reading EKG’s

- “Data Gathering” – steps 1-4
  - 1. Standardization – make sure paper and paper speed is standardized
  - 2. Heart Rate
  - 3. Intervals – PR, QT, QRS width
  - 4. Axis – normal vs. deviation
11 Step Method for Reading EKG’s

• “Diagnoses”
  – 5. Rhythm
  – 6. Atrioventricular (AV) Block
  – 7. Bundle Branch Block or Hemiblock
  – 8. Preexcitation
  – 9. Enlargement and Hypertrophy
  – 10. Coronary Artery Disease
  – 11. Utter Confusion

• The Only EKG Book You’ll Ever Need
  Malcolm S. Thaler, MD
Heart Rate

• Regular Rhythms

**R to R Method Example**

Count total seconds between two R waves:

divide into 60:

Reminder: 1 small box = 0.04 sec

60 Total secs
19.5 x .04 s = .78 s

77 beats/min
Heart Rate

- Irregular Rhythms

5 big boxes = 1 sec
1 ECG = 10 sets of 5 big boxes
Therefore one ECG = 10 secs

Rate = BPM or R Waves/60secs
1 ECG x 6 = 1 min
Count up R waves in one ECG x 6 = BPM
Intervals

- Measure length of PR interval, QT interval, width of P wave, QRS complex

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR interval</td>
<td>0.12 – 0.20 sec</td>
</tr>
<tr>
<td>QRS duration</td>
<td>0.08 – 0.10 sec</td>
</tr>
<tr>
<td>QT interval</td>
<td>0.4 – 0.43 sec</td>
</tr>
<tr>
<td>RR interval</td>
<td>0.6 – 1.0 sec</td>
</tr>
</tbody>
</table>
QTc

- QTc = QT interval corrected for heart rate
  - Uses Bazett’s Formula or Fridericia’s Formula

\[
\text{QTc (Bazett)} = \frac{QT}{\sqrt{RR}}
\]

\[
\text{QTcF} = \frac{QT}{\sqrt[3]{RR}}
\]

- Long QT syndrome – inherited or acquired (>75 meds); torsades de ponites/VF; syncope, seizures, sudden death
Axis
Rhythm

• 4 Questions
  – 1. Are normal P waves present?
  – 2. Are QRS complexes narrow or wide (≤ or ≥ 0.12)?
  – 3. What is relationship between P waves and QRS complexes?
  – 4. Is rhythm regular or irregular?

• Sinus rhythm = normal P waves, narrow QRS complexes, 1 P wave to every 1 QRS complex, and regular rhythm
Types of Arrhythmias

• Arrhythmias of sinus origin
• Ectopic rhythms
• Conduction Blocks
• Preexcitation syndromes
AV Block

• Diagnosed by examining relationship of P waves to QRS complexes
• First Degree – PR interval > 0.2 seconds; all beats conducted through to the ventricles
• Second Degree – only some beats are conducted through to the ventricles
  – Mobitz Type I (Wenckebach) – progressive prolongation of PR interval until a QRS is dropped
  – Mobitz Type II – All-or-nothing conduction in which QRS complexes are dropped without PR interval prolongation
• Third Degree – No beats are conducted through to the ventricles; complete heart block with AV dissociation; atria and ventricles are driven by individual pacemakers
Heart Blocks

Constant P-R interval
- First Degree Heart Block

Variable P-R interval
- Second Degree Heart Block Type I
- Second Degree Heart Block Type II
- Third Degree Heart Block
Bundle Branch Blocks

- Diagnosed by looking at width and configuration of QRS complexes
Bundle Branch Blocks

• **RBBB criteria:**
  – 1. QRS complex > 0.12 seconds
  – 2. RSR’ in leads V1 and V2 (rabbit ears) with ST segment depression and T wave inversion
  – 3. Reciprocal changes in leads V5, V6, I, and aVL

• **LBBB criteria:**
  – 1. QRS complex > 0.12 seconds
  – 2. Broad or notched R wave with prolonged upstroke in leads V5, V6, I, and aVL with ST segment depression and T wave inversion.
  – 3. Reciprocal changes in leads V1 and V2.
  – 4. Left axis deviation may be present.
Bundle Branch Blocks

RBBB

LBBB

Anterior

Lateral

bundle Branch Block

Left bundle branch block

Right bundle branch block

Fig. 11-13

KMc
Hemiblocks

- Diagnosed by looking at right or left axis deviation

- Left Anterior Hemiblock
  - 1. Normal QRS duration and no ST segment or T wave changes
  - 2. Left axis deviation greater than -30°
  - 3. No other cause of left axis deviation is present

- Left Posterior Hemiblock
  - 1. Normal QRS duration and no ST segment or T wave changes
  - 2. Right axis deviation
  - 3. No other cause of right axis deviation is present
Bifascicular Block

• RBBB with LAH
  – RBBB – QRS > 0.12 sec and RSR’ in V1 and V2 with LAH – left axis deviation

• RBBB with LPH
  – RBBB – RS > 0.12 sec and RSR’ in V1 and V2 with LPH – right axis deviation
Preexcitation

• Wolff-Parkinson-White (WPW) Syndrome
  – 1. PR interval < 0.12 sec
  – 2. Wide QRS complexes
  – 3. Delta waves seen in some leads

• Lown-Ganong-Levine (LGL) Syndrome –
  – 1. PR interval < 0.12 sec
  – 2. Normal QRS width
  – 3. No delta wave

• Common Arrhythmias
  – Paroxysmal Supraventricular Tachycardia (PSVT) – narrow QRS’s are more common than wide QRS’s
  – Atrial Fibrillation – can be rapid and lead to ventricular fibrillation
Preexcitation

**WPW**

- Normal electrical pathways
- Abnormal electrical pathway in Wolff-Parkinson-White syndrome

**LGL**

- Lown Ganong Levine Syndrome

Electrocardiogram examples:
- WPW syndrome ECG
- LGL syndrome ECG
Supraventricular Arrhythmias

- **PSVT** – regular; P waves retrograde if visible; rate 150-250 bpm; carotid massage: slows or terminates
- **Flutter** – regular; saw-toothed pattern; 2:1, 3:1, 4:1, etc. block; atrial rate 250-350 bpm; ventricular rate ½, ⅓, ¼, etc. of atrial rate; carotid massage: increases block
- **Fibrillation** – irregular; undulating baseline; atrial rate 350 to 500 bpm; variable ventricular rate; carotid massage: may slow ventricular rate
- **Multifocal atrial tachycardia (MAT)** – irregular; at least 3 different P wave morphologies; rate –usually 100 to 200 bpm; sometimes < 100 bpm; carotid massage: no effect
- **PAT** – regular; 100 to 200 bpm; characteristic warm-up period in the automatic form; carotid massage: no effect, or mild slowing
Supraventricular Arrhythmias

- Atrial fibrillation
- Atrial flutter
- Multifocal atrial tachycardia

**Table 4-3: Characteristics of Supraventricular Tachycardia (SVT)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>150-250 beats/min</td>
</tr>
<tr>
<td>Rhythm</td>
<td>Regular</td>
</tr>
<tr>
<td>P waves</td>
<td>Atrial P waves may be observed that differ from sinus P waves</td>
</tr>
<tr>
<td>PR interval</td>
<td>If P waves are seen, the PRI will usually measure 0.12-0.20 sec</td>
</tr>
<tr>
<td>QRS duration</td>
<td>Less than 0.10 sec unless an intraventricular conduction delay exists</td>
</tr>
</tbody>
</table>
## Rules of Aberrancy

<table>
<thead>
<tr>
<th></th>
<th>Ventricular Tachycardia</th>
<th>Paroxysmal supraventricular Tachycardia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical Clues</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical History</td>
<td>Diseased heart</td>
<td>Usually normal heart</td>
</tr>
<tr>
<td>Carotid Massage</td>
<td>No response</td>
<td>May terminate</td>
</tr>
<tr>
<td>Cannon A Waves</td>
<td>May be present</td>
<td>Not seen</td>
</tr>
<tr>
<td><strong>EKG Clues</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AV Dissociation</td>
<td>May be seen</td>
<td>Not seen</td>
</tr>
<tr>
<td>Regularity</td>
<td>Slightly irregular</td>
<td>Very regular</td>
</tr>
<tr>
<td>Fusion Beats</td>
<td>May be seen</td>
<td>Not seen</td>
</tr>
<tr>
<td>Initial QRS deflection</td>
<td>May differ from normal QRS complex</td>
<td>Same as normal QRS complex</td>
</tr>
</tbody>
</table>
Ventricular Arrhythmias

- VT - Ventricular Tachycardia
- VF - Ventricular Fibrillation

PVC’s

Torsades de Pointes
Atrial Enlargement

• Look at P waves in leads II and V1
• Right atrial enlargement (P pulmonale)
  – 1. Increased amplitude in first portion of P wave
  – 2. No change in duration of P wave
  – 3. Possible right axis deviation of P wave
• Left atrial enlargement (p mitrale)
  – 1. Occasionally, increased amplitude of terminal part of P wave
  – 2. More consistently, increased P wave duration
  – 3. No significant axis deviation
Ventricular Hypertrophy

- Look at the QRS complexes in all leads
- Right ventricular hypertrophy (RVH)
  - 1. RAD > 100°
  - 2. Ratio of R wave amplitude to S wave amplitude > 1 in V1 and < 1 in V6
- Left ventricular hypertrophy (LVH)

<table>
<thead>
<tr>
<th>Precordial Criteria</th>
<th>Limb Lead Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>R wave in V5 or V6 + S wave in V1 or V2 &gt; 35 mm</td>
<td>R wave in aVL &gt;13 mm</td>
</tr>
<tr>
<td>R wave in V5 &gt; 26 mm</td>
<td>R wave in aVF &gt; 21 mm</td>
</tr>
<tr>
<td>R wave in V6 &gt; 18 mm</td>
<td>R wave in I &gt; 14 mm</td>
</tr>
<tr>
<td>R wave in V6 &gt; R wave in V5</td>
<td>R wave in I + S wave in III &gt; 25 mm</td>
</tr>
</tbody>
</table>
Myocardial Infarction

• Dx – Hx, PE, serial cardiac enzymes, serial EKG’s

• 3 EKG stages of acute MI
  – 1. T wave peaks and then inverts
  – 2. ST segment elevates
  – 3. Q waves appear
Q Waves

• Criteria for significant Q waves
  – Q wave > 0.04 seconds in duration
  – Q wave depth > \( \frac{1}{3} \) height of R wave in same QRS complex

• Criteria for Non-Q Wave MI
  – T wave inversion
  – ST segment depression persisting > 48 hours in appropriate clinical setting
Localizing MI on EKG

- **Inferior infarction** – leads II, III, aVF
  - Often caused by occlusion of right coronary artery or its descending branch
  - Reciprocal changes in anterior and left lateral leads
- **Lateral infarction** – leads I, aVL, V5, V6
  - Often caused by occlusion of left circumflex artery
  - Reciprocal changes in inferior leads
- **Anterior infarction** – any of the precordial leads (V1- V6)
  - Often caused by occlusion of left anterior descending artery
  - Reciprocal changes in inferior leads
- **Posterior infarction** – reciprocal changes in lead V1 (ST segment depression, tall R wave)
  - Often caused by occlusion of right coronary artery
Localizing MI on EKG
ST segment

• Elevation
  – Seen with evolving infarction, Prinzmetal’s angina
  – Other causes – J point elevation, apical ballooning syndrome, acute pericarditis, acute myocarditis, hyperkalemia, pulmonary embolism, Brugada syndrome, hypothermia

• Depression
  – Seen with typical exertional angina, non-Q wave MI
  – Indicator of + stress test
Electrolyte Abnormalities on EKG

• Hyperkalemia – peaked T waves, prolonged PR, flattened P waves, widened QRS, merging QRS with T waves into sine wave, VF
• Hypokalemia – ST depression, flattened T waves, U waves
• Hypocalcemia – prolonged QT interval
• Hypercalcemia – shortened QT interval
Drugs

• Digitalis
  – Therapeutic levels – ST segment and T wave changes in leads with tall R waves
  – Toxic levels – tachyarrhythmias and conduction blocks; PAT with block is most characteristic.

• Multiple drugs associated with prolonged QT interval, U waves
  – Sotalol, quinidine, procainamide, disopyramide, amiodarone, dofetilide, dronedarone, TCA’s, erythromycin, quinolones, phenothiazines, various antifungals, some antihistamines, citalopram (only prolonged QT interval – dose-dependent)
EKG Δ’s in other Cardiac Conditions

• Pericarditis – Diffuse ST segment elevations and T wave inversions; large effusion may cause low voltage and electrical alternans (altering QRS amplitude or axis and wandering baseline)

• Myocarditis – conduction blocks

• Hypertrophic Cardiomyopathy – ventricular hypertrophy, left axis deviation, septal Q waves
EKG Δ’s in Pulmonary Disorders

• COPD – low voltage, right axis deviation, and poor R wave progression.
• Chronic cor pulmonale – P pulmonale with right ventricular hypertrophy and repolarization abnormalities
• Acute pulmonary embolism – right ventricular hypertrophy with strain, RBBB, and S1Q3T3 (with T wave inversion). Sinus tachycardia and atrial fibrillation are common.
EKG Δ’s in Other Conditions

• Hypothermia – Osborn waves, prolonged intervals, sinus bradycardia, slow atrial fibrillation, beware of muscle tremor artifact

• CNS Disease – diffuse T wave inversion with T waves wide and deep, U waves

• Athlete’s Heart – sinus bradycardia, nonspecific ST segment and T wave changes, RVH, LVH, incomplete RBBB, first degree or Wenckebach AV block, possible supraventricular arrhythmia
Utter Confusion

• Verify lead placement
• Repeat EKG
• Repeat standardized process of EKG analysis—starting over from the beginning with basics – rate, intervals, axis, rhythm, etc. and proceed through entire stepwise analysis
• Consider Cardiology consultation
Arrhythmia Indications to Consult Cardiology

- Diagnostic or management uncertainty
- Medications not controlling symptoms
- Patient is in high-risk occupation or participates in high-risk activities (pilot, scuba driving)
- Patients prefers intervention over long-term meds
- Preexcitation
- Underlying structural heart disease
- Associated syncope or other significant symptoms
- Wide QRS
Care Considerations Prior to Cardiology Consult

- Thorough Hx and PE
- Basic labs
- EKG and repeat EKG
- Holter monitor
- Echocardiogram
- Acuity of care required – consider risks, hemodynamic stability
Pacemaker Considerations

- Third-degree (complete) AV block
- Symptomatic lesser degree AV block or bradycardia
- Sudden onset of various combinations of AV block and BBB during acute MI
- Recurrent tachycardias that can be overdriven and terminated by pacemakers
Osteopathic Considerations

• Treatments –
  – Lymphatics – thoracic inlet, abdominal diaphragm, rib raising, lymphatic pumps
  – Sympathetics (T1-T6) – cervical ganglion, rib raising, T1-T6, Chapman’s reflexes, T10-L2 for adrenal/kidney
  – Parasympathetics – OA/AA/cranial – vagus nerve
Clinical Cases/EKG’s
Case 1

- 53 year old caucasian female with 4 day hx of severe central chest pain on exertion, previously alleviated with rest; now worsened over last 24 hours and sustained at rest
- PMHx – DM2, HTN, hyperlipidemia
- Appears unwell, in pain, sweaty, and grey
Case 1

- Diagnosis? EKG findings?
Case 1

- Acute anterior ST-elevation MI with “tombstone” or “fireman’s hat” in V1-V4
- Tx? Localization?
Case 1

- PCI stenting of LAD

- Post-procedure = resolving ST elevation; loss of ominous tombstone effect; Q waves developing
Case 2

• 45 yo male presents with acute SOB s/p long vacation in Paris
• PMHx - asthma, Crohn’s disease, anxiety, GERD, tobacco abuse
• VS 37, 148/92, 130, 26
• Patient appears uncomfortable but otherwise unremarkable exam
Case 2

- Diagnosis? EKG findings?
Case 2

- Acute PE with sinus tachycardia, a PVC, and S1Q3T3 pattern
Case 3

• 72 yo male presents to the office for evaluation prior to cataract surgery
• No complaints
• PMHx – B/L cataracts, OA, HTN, hyperlipidemia, and chronic low back pain
• VS 37.2, 152/86, 74, 14
Case 3

- Diagnosis? EKG findings?
Case 3

• LVH – QRS voltage criteria in precordial leads and repolarization changes in V5, V6
Case 4

• 27 yo female presents to the ED with c/o chest discomfort and palpitations after studying all night for graduate school exams
• Appears nervous and “uneasy” with rapid pulse
• PMHx – unremarkable; no meds, admits to occasional alcohol, non-smoker, denies illicit drug use, used coffee to stay awake to study
Case 4

• Diagnosis? EKG findings?
Case 4

- SVT – regular, narrow-QRS tachycardia, rate of 160 bpm
Case 5

- 46 yo male presents to ED with c/o severe HA persisting over 5 hours despite acetaminophen and NSAID attempts as abortive therapy
- PMHx – occasional left shoulder pain, non-smoker
- Construction worker
- VSS; unremarkable exam
Case 5

- Diagnosis? EKG findings?
Case 5

- Normal EKG
Case 6

• 56 yo female presents to family physician with c/o light-headedness and occasional flutter in her chest
• PMHx – anxiety, depression, obesity, smoker
• Works as retail store manager
• VSS; course breath sounds, otherwise unremarkable exam
Case 6

- Diagnosis? EKG findings?
Case 6

• Second degree AV block – Mobitz Type I – Wenckebach (specifically 3:2 AV Wenckebach phenomenon where every 3\textsuperscript{rd} P wave is blocked)
Case 7

- 28 yo male presents for commercial driver’s license (CDL) evaluation
- No complaints
- VSS; asymptomatic; exam without significant findings
Case 7

- Diagnosis? EKG findings?
Case 7

- Typical preexcitation (WPW) pattern
- Short PR interval and delta waves in many leads
- Tx is close observation unless patient has had SVT or atrial fibrillation which indicates tx with ablation of accessory pathway
Case 8

• 32 yo male presents to ED with c/o feeling sick for the last 6 days
• Symptoms include fevers, cough, and difficulty catching his breath
• PMHx – hyperlipidemia, obesity, metabolic syndrome
• VS 38.1, 105, 128/84, 22
Case 8

- Diagnosis? EKG findings?
Case 8

- Acute pericarditis – diffuse ST elevation with PR segment depression is diagnostic
Case 9

- 67 yo male presents to his cardiologist for outpatient 6 week post-hospital visit
- Previous hospitalization for non-cardiac chest pain
- Post-hospital cardiac meds – ACE inhibitor, beta blocker, aspirin, nitrate
- No current complaints
Case 9

- Diagnosis? EKG findings?
Case 9

- Atrial fibrillation – irregularly irregular without P waves
- RBBB – wide QRS with rsR’ pattern in V1, broad S waves in leads I and aVL
- Inferior infarct – non-acute (> 1 week) pathologic Q waves in inferior leads (II, III, and aVF)
Case 10

- 79 yo male brought to ED via EMS with chest pain, SOB, and near-syncope
- PMHx – unobtainable secondary to patient distress
- VS – 36.9, 140’s, 82/40, 28
Case 10

• Diagnosis? EKG findings?
Case 10

- Monomorphic sustained ventricular tachycardia (VT) – could rapidly deteriorate into VF, torsades de pointes, asystole, or sudden death
Case 11

- 82 yo female admitted to acute care hospital secondary to chest pain
- PMHx – HTN, DM2, CHF, obesity, depression
- Cardiology planning cardiac catheterization secondary to new finding during initial consultation
Case 11

• Diagnosis? EKG findings?
Case 11

- LBBB – wide QRS; broad, notched R wave in V5, V6 and I with ST depression and T wave inversion
Case 12

- 59 yo male presents to ED diaphoretic and in distress
- PMHx – HTN, ESRD, DM2, Left BKA
- VS – 37.5, 108, 96/58, 24
Case 12

- Diagnosis? EKG findings?
Case 12

• Hyperkalemia – tall peaked T waves present throughout; other progressive EKG changes may follow with increasing potassium levels – prolonged PR interval, flattened P waves, widening QRS, sine waves

• Sinus tachycardia also present
Bonus Case

- 18 yo male undergoing military physical exam and evaluation prior to boot camp
- No complaints
- PMHx – denies
- VSS; exam unremarkable
Bonus Case

- Diagnosis? EKG findings?
Bonus Case

• Reversed arm leads – inverted P waves in lead I with normal R wave progression in precordial leads
Board Exam Points

• EKG’s likely to have 1 main finding
• Clinical case likely included with each EKG
• Question likely to focus on clinical case as well as EKG
• Straight forward without tricks or obscure findings (not likely to see “zebras”)
• Focus on common arrhythmias, common cardiac diagnoses, common non-cardiac EKG abnormalities, or emergent “can’t miss” diagnoses
Questions?
Resources

• Sources and Suggested References
  – The Only EKG Book You’ll Ever Need - Malcolm S. Thaler
  – Rapid Interpretation of EKG’s – Dale Dubin, M.D.
  – “…Except for OMT!” – Dale Pratt-Harrington
  – American Family Physician – November 1, 2015
  – Up to Date
  – blog at wordpress.com
  – cme.umn.edu
  – ekgcasestudies.com
  – healio.com
  – lifeinthefastlane.com
  – learntheheart.com