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Objectives

• Review of Cardiac Electrophysiology
• ECG Waves and Intervals
• EKG Leads: Limb, Anterior and Augmented Leads
• The Basics of EKG Interpretation
• Example Cases
Cardiac Electrophysiology

- Sinoatrial node
- Atrioventricular node
- Left posterior bundle
- Right bundle
- Bachmann's bundle
- His bundle
- Purkinje fibres
EKG Waves and Intervals

Skvalen, Wikimedia Commons
EKG Waves and Intervals

• P wave: the *sequential* activation (depolarization) of the right and left atria

• QRS complex: right and left ventricular depolarization (normally the ventricles are activated *simultaneously*)

• ST-T wave: ventricular repolarization
EKG Waves and Intervals

• **U wave**: origin for this wave is not clear - but probably represents "after depolarizations" in the ventricles

• **PR interval**: time interval from onset of atrial depolarization (P wave) to onset of ventricular depolarization (QRS complex)

• **QRS duration**: duration of ventricular muscle depolarization
EKG Waves and Intervals

- QT interval: duration of ventricular depolarization and repolarization
- RR interval: duration of ventricular cardiac cycle (an indicator of ventricular rate)
- PP interval: duration of atrial cycle (an indicator or atrial rate)
Normal Intervals

- **PR**
  - 0.20 sec (less than one large box)

- **QRS**
  - 0.08 – 0.10 sec (1-2 small boxes)

- **QT**
  - 450 ms in men, 460 ms in women
  - Based on sex / heart rate
  - Half the R-R interval with normal HR
Standard Limb Leads
Anterior Limb Leads

- V1: right 4th intercostal space
- V2: left 4th intercostal space
- V3: halfway between V2 and V4
- V4: left 5th intercostal space, mid-clavicular line
- V5: horizontal to V4, anterior axillary line
- V6: horizontal to V5, mid-axillary line

Mikael Häggström, [Wikimedia Commons](https://commons.wikimedia.org/wiki/Mikael_H%C3%A4ggstr%C3%B6m)
Bipolar and Augmented Leads
The Basics of EKG Interpretation

- Rate
- Rhythm
- Axis
- AV Blocks and Intervals
- Bundle Branch Blocks
- Hypertrophy
- Infarction/Ischemia
Rate

• Sinus Rhythm = SA Node Discharge
  – 60-100/min
  – Overdrive Suppresses Automaticity Foci
• HR > 100 = Tachycardia
• HR < 60 = Bradycardia
• Automaticity Foci
  – Atria 60-80/min
  – AV Junction 40-80/min
  – Ventricles 20-40/min
Rate Interpretation

- 1 small box = 0.04 sec
- 1 big box = 0.2 sec or 1/300 min
- For bradycardia use the “3 seconds” marks
- Count cycles in 6 seconds and multiply by 10
Rhythm

• Sinus Rhythm
  – Originating from SA node
  – P wave before every QRS
  – P wave in same direction as QRS
Normal Sinus Rhythm

Sinus Bradycardia

Sinus Tachycardia
Axis Interpretation

- Represents the overall direction of the heart’s activity
- Axis of –30 to +90 degrees is normal
The Quadrant Approach

- QRS up in I and up in aVF = Normal
Atrioventricular Blocks

• AV blocks
  – First degree block
    • PR interval fixed and > 0.2 sec
  – Second degree block, Mobitz type 1 (Wenkebach)
    • PR gradually lengthened, then drop QRS
  – Second degree block, Mobitz type 2
    • PR fixed, but drop QRS randomly
  – Type 3 block
    • PR and QRS dissociated
1\textsuperscript{st} Degree AV Block
2nd Degree AV Block

Mobitz Type I (Wenkebach)

Mobitz Type II
3\textsuperscript{rd} Degree AV Block (Complete Heart Block)
Prolonged QT

• Normal
  – Men 450ms
  – Women 460ms

• Corrected QT (QTc) Calculation
  – QTm/V(R-R)

• Causes
  – Drugs (Na channel blockers)
  – Hypocalcemia, hypomagnesemia, hypokalemia
  – Hypothermia
  – Acute Myocardial Infarction
  – Congenital
  – Increased Intracranial Pressure
Bundle Branch Blocks

• Left Bundle Branch Block
  – Monophasic R wave in I and V6, QRS > 0.12 sec
  – Loss of R wave in precordial leads
  – QRS T wave discordance I, V1, V6
  – Consider cardiac ischemia if a new finding

• Right Bundle Branch Block
  – V1: RSR prime pattern with inverted T wave
  – V6: Wide deep slurred S wave
Left bundle branch block characteristics

V1

rS

V6

R
Right bundle branch block characteristics

V1

V6

rSR'

qRs
Hypertrophy

- Left Ventricular Hypertrophy Criteria:
  - Add the larger S wave of V1 or V2 in mm, to the larger R wave of V5 or V6.
  - Sum is > 35mm = LVH
Ischemia

• Usually indicated by ST changes
  – Elevation = Acute infarction
  – Depression = Ischemia

• Can manifest as T wave changes

• Remote ischemia shown by Q waves
Evolution of Myocardial Ischemia
Coronary Blood Supply
Characteristics of a Myocardial Infarct

A. Anterior Infarction
   A. V1, V2, V3, V4
   B. Left Anterior Descending (LAD)

B. Lateral Infarction
   A. I, AVL
   B. Circumflex branch of Left Coronary Artery

C. Posterior Infarction
   A. Depression in V1, V2, V3
   B. Right Coronary
   C. Provides blood supply to SA Node, AV Node, His Bundle

D. Inferior Infarction
   A. II, III, AVF
   B. Right or Left Coronary
      A. Most Commonly Right Coronary
CLASSIC CARDIAC CASE EXAMPLES
Case # 1

• 29 y/o male presents with chief complaint of “Chest pain”
  – Sharp chest pain localized to sub-sternal region
  – Pleuritic - worse w/ deep breathing, no radiation
  – Associated with shortness of breath
  – No nausea or diaphoresis
  – Recent low-grade fever, chills
  – No abdominal pain, vomiting, diarrhea
Case # 1

• Physical Exam
  – T = 38.2, P=100, BP = 115/75, RR = 12, SaO2 = 98%
  – GENERAL: A+O x 3, NAD
  – HEENT: NC/AT, PERRL, EOMI, OP Clear
  – NECK: Supple, No LAD
  – HEART: RRR, No Murmurs, Gallops
  – LUNGS: CTA bilaterally
  – ABD: Soft, ND, NT, No masses
  – EXT: WWP, 2+ Pulses
  – NEURO: A+O x 3, No focal Neuro Deficits
Pericarditis

• EKG Findings
  – Diffuse Concave ST Elevation
  – Concordant T wave changes w/ ST segment
  – ST Depression in aVR, V1
  – PR Depression
  – No Reciprocal Changes
Case # 2

• 46 y/o male presents with CC of Syncope
  – Patient reports he was standing at sink in kitchen and felt lightheaded
  – Patient noted chest pressure and tightness in sub-sternal region
  – No radiation. No nausea or diaphoresis.
  – Patient passed out and LOC x 2 min. No seizure activity.
  – Patient continues to note shortness of breath, lightheadedness and near syncopral sensation
• Past Medical History: Diabetes, Coronary Artery Disease, Myocardial Infarction
• Meds: Aspirin, Plavix, Metoprolol, Lipitor
• Allergies: NKDA
• SH: + Smoker, No ETOH, No IVDU
Case # 2

• Physical Exam
  – VS: T=37.6, P = 30, BP = 85/45, RR = 12, O2 sat = 97%
  – GEN: Drowsy, no respiratory distress
  – HEENT: NC/AT, PERRL, EOMI, OP Clear
  – NECK: Supple, No LAD
  – HEART: Bradycardic, regular, No Murmurs
  – LUNGS: CTA b/l. No Wheezes/Rales.
  – ABD: BS+, Soft, NT, ND, no masses
  – EXT: Thready pulses, no cyanosis. No edema.
  – NEURO: Drowsy. No focal deficits.
Complete Heart Block

• Complete dissociation of atrial and ventricular activity
• Results from conduction block
  – Level of the AV node
  – Bundle of His
  – Purkinje fibers
• Treatment
  – Atropine
    • Use Cautiously in patients w/ MI and wide QRS complexes
  – Transcutaneous Pacing
  – Transvenous Pacing
EKG PRACTICE
# Differential Diagnosis of Tachycardia

<table>
<thead>
<tr>
<th>Tachycardia</th>
<th>Narrow Complex</th>
<th>Wide Complex</th>
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<tbody>
<tr>
<td>Regular</td>
<td>ST</td>
<td>ST w/ aberrancy</td>
</tr>
<tr>
<td></td>
<td>SVT</td>
<td>SVT w/ aberrancy</td>
</tr>
<tr>
<td></td>
<td>Atrial flutter</td>
<td>VT</td>
</tr>
<tr>
<td>Irregular</td>
<td>A-fib</td>
<td>A-fib w/ aberrancy</td>
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<tr>
<td></td>
<td>A-flutter w/ variable conduction</td>
<td>A-fib w/ WPW</td>
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<tr>
<td></td>
<td>MAT</td>
<td>VT</td>
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</tbody>
</table>
Atrial Flutter
Atrial Fibrillation
Wide Complex Tachycardia

• Differential Diagnosis
  – Ventricular Tachycardia
  – SVT with Aberrancy
Supraventricular Tachycardia

Retrograde P waves

Narrow complex, regular; retrograde P waves
ATRIAL FLUTTER WITH VARIABLE BLOCK
ANTEROSEPTAL MYOCARDIAL INFARCTION
INFERIOR POSTERIOR MYOCARDIAL INFARCTION
MASSIVE AMI!!!!
POLYMORPHIC VENTRICULAR TACHYCARDIA
TORSADES DE POINTES
VENTRICULAR FIBRILLATION
(Most Likely, Monomophric Ventricular Tachycardia)

WIDE COMPLEX TACHYCARDIA
SVT WITH SIGNS OF RATE DEPENDENT ISCHEMIA
Hypokalemia

U waves; Can also see PVCs, ST depression, small T waves
Hyperkalemia

Tall, narrow and symmetric T waves
Questions?

Dksully, Flickr