Basics - Physiology
- The heartbeat creates many cellular depolarizations
- When going toward positive leads, get positive deflections
- When going away from positive leads, get negative deflections
- EKG is a summation measurement of many cellular events

Basics – “Alphabet”
- The first upward deflection is the P wave
  - It represents atrial depolarization
- The PR Interval is the time between atrial and ventricular depolarization
- The QRS complex represents ventricular depolarization
- The ST segment is next
- The T wave represents ventricular repolarization

Review “Alphabet”

QRS Nomenclature
- Upward deflection is an R wave
- A second positive deflection is given a prime designation - RSR’
- A downward deflection preceding an R is a Q wave
- A downward deflection that follows an R is an S wave
- If only negative deflection is present it is a QS complex
- Ventricular depolarization is called “QRS”
  Although not all parts may be present
Examples of QRS Complexes

Basics - Standards
- Three limb leads
  I, II, III
- Three augmented limb leads
  aVR, aVL, aVF
- Six chest leads
  V1 - V6

Basics – Standard Form

<table>
<thead>
<tr>
<th>I</th>
<th>aVR</th>
<th>V1</th>
<th>V4</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>aVL</td>
<td>V2</td>
<td>V5</td>
</tr>
<tr>
<td>III</td>
<td>aVF</td>
<td>V3</td>
<td>V6</td>
</tr>
</tbody>
</table>

Rhythm strip (II or V1, usually – the atrial leads)

Basics - Strip
- Big box = 200 msec (0.2 sec)
  5 small boxes
- Little box = 40 msec (0.04 sec)
  Also 1 mm

Review of Boxes

“The System”

Only one of many ways to do this!
Caveats
- Difficult to do in groups
  - Everyone is at a different level
- Lots of material in a compressed session
  - Your brain will “get full” before we finish!
  - The handout is more complete than you need

We will not cover “Cool Arrhythmias”
- Remembering criteria is not expected
  - Or even encouraged until you’re ready
- Shoot for “Normal” vs. “Not Normal”
- The only pattern to learn is “Normal”!
- You have everything in the handout
- Keep Calm and Carry On!

The Basic Structure
- Validity
- Rate
- Rhythm
- Axis
- Hypertrophy
- Ischemia/Infarction

Review
- Validity
- Rate
- Rhythm
- Axis
- Hypertrophy
- Ischemia/Infarction

Validity
- Clinical context for test, right patient, etc
  - When handed an EKG, ask …
    - "Why was this done?" and
    - "How is the patient?"
- Look for voltage standardization curve
  - Two big boxes tall, or 10 mm/mV
  - Is also at the bottom of the strip

Standardization Box
Validity
- QRS in Lead I should be opposite that in AVR
- And QRS is + in Lead I
- R-wave should progress in chest (V) leads such that by V4 the R-wave is most prominent
  Represents the left ventricle
- Review an old EKG

An “issue” noted in validity does not necessarily mean the tracing is invalid
- Any abnormalities should generate “Differential Diagnoses”

Poor R wave progression
• Differential Dx?

Poll Question: The heart rate is closest to:
1. 150
2. 100
3. 75
4. 60
5. 50
Rate
- Normal rate 60-100
  - <60 bradycardia
  - >100 tachycardia
- Basic pacing rates:
  - Atria 80/min
  - Junctional 60/min
  - Ventricular 40/min
  - But a rate does NOT determine pacer

Rate Calculation
- Rate = 300/# of large boxes between R-waves, or
- Memorize: 300, 150, 100, 75, 60, 50, 43, 37
  - Count at each large box after first R

The heart rate is closest to:
1. 150
2. 100
3. 75
4. 60
5. 50

Cumulative Review
- Validity
  - Context
  - Standardization box
  - I and aVR
  - R wave progression
  - Old EKG
- Rate
  - 300, 150, 100, 75, 60, 50, 43, 37
Poll Question: Is this a sinus rhythm?

1. Yes
2. No

Rhythm – Basic Questions
- Is it REGULAR?
- Is it SINUS?
- What are the INTERVALS?
  - PR
  - QRS
  - QT

Rate & Rhythm
- Truly done as “Gestalt”
  - Learning steps so you will usually
  - Implement by steps (with pauses)
  - How to cut your time in half!
- Look at rhythm strip for both
- Trust your eyes for “not normal”

Rhythm - Regularity
- Regular (usually “Fairly regular”)
- Regularly irregular
  - Group or pattern beating
  - Predictable
- Irregularly irregular
  - Chaotic
  - Unpredictable

Rhythm - Sinus
- Often hear: P before QRS, QRS after P
- This really means an atrial relationship to ventricles
- What are the Atrial leads?
- For SINUS rhythm must also have...

Rhythm - Sinus
- A positive P wave in II
- A pacer from the SA node (sinus) should always be positive if
  - Leads placed correctly and
  - No dextrocardia
- The why is a “Pearl”
Rhythm - Sinus

- Wide vs. Narrow QRS is clinically important
- Covered in Handout
- Not covered here
- Next level after “Foundation” work

Rhythm - Intervals

- Check PR interval
- Start of P to start of QRS
- Normal is 0.12-0.20 sec
- 3 –5 small boxes

PR Interval

Start
Finish at 4 small boxes: 0.16

Rhythm - Intervals

- First degree AV block, PR > .20
- Second degree AV block
  - Mobitz type I (Wenkebach)
  - Mobitz type II
- Third degree AV block
- PR interval can also be too fast
  - Accessory pathway
  - WPW, LGL, etc

Rhythm - Intervals

- Really cool stuff!!
- We won’t talk about it
- Get the basics down before taking on weird rhythms

By the Way...

- First
  - Validity
- Second
  - Rate
- Third
  - Rhythm
Rhythm - Intervals
- Check QRS width
  - Start of complex to end
  - Normal 0.10-0.12
  - 2 ½ to 3 small boxes
  - Look at QRS morphology, too
  - Should be crisp, single line

Rhythm - Intervals
- If QRS is wide, then
  - By definition a Bundle Branch Block
  - RSR’ in V1, V2 is RBBB
  - in V5, V6 is LBBB

Rhythm - Intervals
- If RSR’ present, or
  - QRS is “slurred” or has “shoulder”, but
  - Interval not wide or prolonged...

Rhythm - Intervals
- Interventricular Conduction Delay
  - IVCD, or
  - “Early BBB”, or
  - “Incomplete BBB”
  - Clinical Relevance?
Rhythm - Intervals
- Handout has more on BBB
- IVCD
- Hemiblocks
- Not foundation material

Rhythm - Intervals
- Check QT interval
  - Start of QRS to end of T
  - Depolarization to repolarization
  - For rate between 60 - 100,
  - QT < 1/2 R-R interval
  - Around 0.36-0.44 sec
  - Very clinically important
  - R on T phenomenon

QT Interval
Rate about 80, so...
First R
Second R
Halfway: 0.36

Is this a sinus rhythm?
1. Yes
2. No

Cumulative Review
- Validity
- Context
- Standardization box
- I and aVR
- R wave progression
- Old EKG
- Rate
  - 300, 150, 100, 75, 60, 50, 43, 37
- Rhythm
  - Regular or not
  - Sinus or not
  - Intervals

Brain Alert!
It's getting full...
Poll Question: The axis is in which quadrant?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>1.</td>
<td>Normal</td>
</tr>
<tr>
<td>2.</td>
<td>LAD</td>
</tr>
<tr>
<td>3.</td>
<td>RAD</td>
</tr>
<tr>
<td>4.</td>
<td>Indeterminate</td>
</tr>
<tr>
<td>5.</td>
<td>Not sure</td>
</tr>
</tbody>
</table>

Axis

- Use I and aVF for quick scan
- The thumb method
- Normal is + QRS in both
  - Two thumbs up
- + in I, - in aVF
  - Left Axis Deviation (LAD)

In which Quadrant is the Axis?

Axis

- - in I, + in aVF
  - Right Axis Deviation (RAD)
- - in I, - in aVF
  - Really not normal!
  - Differential?

In which Quadrant is the Axis?

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>I –</td>
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</tr>
<tr>
<td>F +</td>
<td>F +</td>
</tr>
<tr>
<td>RAD</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Axis

- Main goal now is to identify normal axis or not
- But work to be more specific with respect to degree of axis
- Why?
Axis

- Normal: 0 to +90 degrees
- Leftward (or LAD): 0 to -29
- LAD: -30 or more degrees
- RAD: > or = +90 degrees

Strive to give degree measurement
Look for isoelectric lead
As much + as – deflection
The axis is perpendicular to it

What is the Axis?

Positive in I
Lead II 60
Perpendicular lead
Positive in aVF

The axis is in which quadrant?

1. Normal
2. LAD
3. RAD
4. Indeterminate
5. Not sure
Poll Question: What hypertrophy is suggested in V1?

1. None
2. LAE
3. RAE
4. LVH
5. RVH

Hypertrophy

- **Atrial**
  - Must have sinus rhythm!
  - Look at P wave in leads II and V1
- **Ventricular (Many criteria exist)**
  - Cannot do with a BBB
  - Look at QRS in chest leads

Hypertrophy - Atrial

- Normal P wave
  - Smooth in morphology
  - < 2 1/2 small boxes high and wide (II)
  - In V1
    - Can be all positive
    - Can be symmetrically biphasic
    - Left atrium has a little more muscle
    - Determines time of conduction
- **RAA**
  - Lead II:
    - Tall P-wave (>2.5 mm)
    - “P-pulmonale”
  - V1:
    - Large tall P
    - Tall in both!

P Wave of RAA

- **LAA**
  - Lead II:
    - P-wave with notching
    - “P-mitrale”
  - V1:
    - Mainly or purely negative P-wave
P Waves of LAA

Hypertrophy - Ventricular
- Multiple criteria exist
- Included in handout
- Trust your eyes for size

Hypertrophy - Ventricular
- RVH
  - Found in validity evaluation
  - “Big” R wave in V1 (6-7 mm)
    - Normal pattern: No R in V1
  - “Deep” S wave in V6 (6-7 mm)
    - Normal pattern: No S in V6
  - Included in differential of RAD

Hypertrophy - Ventricular
- LVH
  - Suggested in first scan of EKG
  - One method (Sokolow) is to
    - Look at biggest R in V5 or V6, plus
    - Biggest S in V1 or V2
    - LVH suggested if > 35mm in adult

LVH Example
- Deepest S: 18 mm
- Tallest R: 40 mm

What hypertrophy is suggested in V1?
1. None
2. LAE
3. RAE
4. LVH
5. RVH
Major Brain Default

Overload imminent!
Abort!

Basic Cumulative Review
- Validity
- Rate
- Rhythm
- Axis
- Hypertrophy

Poll Question: This EKG suggests
1. Normal
2. Anterior MI
3. Lateral MI
4. Septal ischemia
5. Inferolateral ischemia

Ischemia/Infarction
- Check all leads for:
  - Q waves
  - ST segment changes
  - T wave changes
- Look in groups of leads

T Waves
- Usually QRS and T are upright together
- T waves should be upright in V 2-6
  Can be normally inverted in V 1
- T wave inversion is first sign of ischemia
- Peaked T wave is first sign of acute injury or high K+

ST Segment Changes
- Differential for ST Depression
  - Ischemia
  - Subendocardial infarct
  - "Strain" from hypertrophy
- Drug effect
  - Digoxin
Changes of Ischemia

- T wave inversion
- ST depression

ST Segment Changes

- Elevation is Acute injury
- If no Q waves then non-Q wave infarction
- If associated with Q waves
  - Likely transmural infarct
  - Much less common now - thrombolytics

Non Q Wave Infarction

- Now called “Non-ST Elevation MI” or NSTEMI

Summary of Changes

- Repolarization most sensitive part of cycle
- T wave changes are first
- ST segment follows T wave
- Q waves can be bad, but also normal!

Dynamic Summary

- The “Dance”
- Visual demonstration

Dynamic Summary

- Ischemia:
  - T wave inversion, pulls
  - ST segment down (depression)
  - If continues, then ...
Dynamic Summary

- Injury:
  - T wave peaks (hyperacute T wave), which pulls
  - ST segment up (elevation)
  - Represents Cardiac muscle at risk
  - If injury continues, then...

Dynamic Summary

- T wave inverts again (tombstoning)
- If continues, then...
- Infarction

Dynamic Summary

- Infarction:
  - Q wave appears (irrev cell death)
  - If continues...
  - Q wave enlarges and ST seg returns to baseline
  - T wave inversion is the last thing to return to "normal"

Dynamic Summary

- The whole process is a continuum
- Acute Coronary Syndrome
  - Includes angina
  - Ischemia
  - Injury
  - Infarction

Q/ST changes in Lead Groups (Artery)

- Septal (LAD):
  - Changes in V1-V2
- Anterior (LAD):
  - V3-V4
- Lateral (Circumflex):
  - I, aVL, V5-V6
- Inferior (RCA or Circumflex):
  - II, III, aVF
- Posterior (RCA): Large R with ST depression V1, V2

This EKG suggests

1. Normal
2. Anterior MI
3. Lateral MI
4. Septal ischemia
5. Inferolateral ischemia
Captain, she’s gonna blow!

Not to worry
You now know this stuff

Summary
- Validity
- Context
- Standardization box
- I and aVR
- R wave progression
- Compare with old EKG

Summary
- Rate
  - 300
  - 150
  - 100
  - 75
  - 60
  - 50
  - 43
  - 37

Summary
- Rhythm
  - Regular or not
  - Sinus or not
  - Intervals evaluated
    - PR
    - QRS
    - QT

Summary
- Axis
  - I and aVF
  - Normal Quadrant or Not (Axis Deviation)
  - Isoelectric lead next to get degree of axis
  - Work to give degree measurement!

Summary
- Hypertrophy
  - Atrial
    - Look at P wave in leads II and V 1
  - Ventricular
  - Many criteria exist
Summary

- Ischemia
  - T wave inversion
  - ST segment depressed
- Injury
  - Peaked T wave (maybe)
  - ST segment elevated (maybe)
- Cell death
  - Q wave forms

That’s Enough!

Now, be careful out there!

Q&A

Let your voice be heard!

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